CSEDU 2014

6th INTERNATIONAL CONFERENCE ON COMPUTER SUPPORTED EDUCATION

PROCEEDINGS

VOLUME 1

1 - 3 APRIL, 2014

BARCELONA, SPAIN

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CSEDU 2014

Proceedings of the
6th International Conference on
Computer Supported Education

Volume 1

Barcelona, Spain

1 - 3 April, 2014

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Open Education Europa
Internet Multimedia Search and Mining

Edited by Susan Zvacek, Maria Teresa Restivo, James Uhomoibhi and Markus Helfert

Printed in Portugal

ISBN: 978-989-758-020-8

Depósito Legal: 372332/14

http://www.csedu.org

csedu.secretariat@insticc.org

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Selected Papers Book

A number of selected papers presented at CSEDU 2014 will be published by Springer-Verlag in a CCIS Series book. This selection will be done by the Conference Chair and Program Co-chairs, among the papers actually presented at the conference, based on a rigorous review by the CSEDU 2014 Program Committee members.

Foreword

This book contains the proceedings of the 6th International Conference on Computer Supported Education (CSEDU 2014) which was organized and sponsored by the Institute for Systems and Technologies of Information, Control and Communication (INSTICC). This conference was held in Cooperation with the Association for Computing Machinery - Special Interest Group for Information Technology Education, European Council for Business Education (ECBE) and Association des Technologies de l'Information pour l'Education et la Formation (ATIEF). The conference was also technically co-sponsored by IEEE Education Society - Capitulo Español and SPEE (Sociedade Portuguesa para a Educação em Engenharia).

CSEDU has become an annual meeting place for presenting and discussing learning paradigms, best practices and case studies that concern innovative computer-supported learning strategies, institutional policies on technology-enhanced learning including learning from distance, supported by technology. The Web is currently a preferred medium for distance learning and the learning practice in this context is usually referred to as e-learning or technology-enhanced learning. CSEDU 2014 provided an overview of the state of the art in technology-enhanced learning and outlined upcoming trends and promoting discussions about the educational potential of new learning technologies in the academic and corporate world.

This conference brought together researchers and practitioners interested in methodologies and applications related to the education field. It had five main topic areas, covering different aspects of Computer Supported Education, including "Information Technologies Supporting Learning", "Learning/Teaching Methodologies and Assessment", "Social Context and Learning Environments", "Domain Applications and Case Studies" and "Ubiquitous Learning". We believe these proceedings demonstrate new and innovative solutions, and highlight technical problems in each field that are challenging and worthwhile.

CSEDU 2014 received 242 paper submissions from 57 countries in all continents. A double-blind review process was enforced, with the help of the 277 experts who were members of the conference program committee, all of them internationally recognized in one of the main conference topic areas. Only 32 papers were selected to be published and presented as full papers, (i.e., completed work, 12 pages in proceedings, 30-minute oral presentations) for a 13% acceptance rate. Another 69 papers, describing work-in-progress, were selected as short papers for 20' oral presentation and 71 papers were presented as posters. All accepted papers represent a high level of quality, which we intend to maintain and reinforce in the next edition of this conference.

The high quality of the CSEDU 2014 programme was enhanced by four keynote lectures, delivered by experts in their fields, including (alphabetically): Erik de Graaff (Aalborg University, Denmark), José Carlos Lourenço Quadrado (ISEL - Lisbon Superior Engineering Institute, Portugal and IFEES - International Federation of Engineering Education Societies, United States), Larissa Fradkin (London South Bank University, Brunel University and Sound Mathematics Ltd., United Kingdom) and Steve Wheeler (Plymouth Institute of Education, Plymouth University, United Kingdom).

For the sixth edition of the conference we extended and ensured appropriate indexing of the proceedings of CSEDU including Thomson Reuters Conference Proceedings Citation Index, INSPEC, DBLP, EI and Scopus. Besides the proceedings edited by SCITEPRESS, a short list of papers presented at the conference will be selected so that revised and extended versions of these papers will be published by Springer-Verlag in a CCIS Series book. Furthermore, all presented papers will soon be available at the SCITEPRESS digital library.

The best contributions to the conference and the best student submissions were distinguished with awards based on the best combined marks of paper reviewing, as assessed by the Program Committee, and the quality of the presentation, as assessed by session chairs at the conference venue.

The conference was complemented with a special session, focusing on Well-being Literacy; named Special Session on Well-being Literacy through Multimedia Education for Vulnerable Populations - WeLL 2014.

Building an interesting and successful program for the conference required the dedicated effort of many people. Firstly, we must thank the authors, whose research and development efforts are recorded here. Secondly, we thank the members of the program committee and additional reviewers for their diligence and expert reviewing. We also wish to include here a word of appreciation for the excellent organization provided by the conference secretariat, from INSTICC, which has smoothly and efficiently prepared the most appropriate environment for a productive meeting and scientific networking. Last but not least, we thank the invited speakers for their invaluable contribution and for taking the time to synthesize and deliver their talks.

Markus Helfert
Dublin City University, Ireland

Susan Zvacek
Fort Hays State University, U.S.A.

Maria Teresa Restivo
FEUP, Portugal

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University of Ulster, U.K.

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Computer Supported Education

The Human Factor

José Carlos Lourenço Quadrado
ISEL - Lisbon Superior Engineering Institute, Portugal
IFEES - International Federation of Engineering Education Societies, U.S.A.

Abstract: Within the Computer Supported Education (CSE) there are three interesting trends observed.
The first one is the conscience that the technical specialisms are becoming increasingly important. New technologies and the emergence of Mobile, Cloud, Continuous Integration & Deployment allow educators with practical hands-on knowledge and experience to be decisive for the success of CSE projects.
On the other hand, it has changed the way we work together with each other. The necessity to have agile replies to the demands of the education stakeholders, to communicate and take responsibility, demands the critical thinking, the exchange of information and the flexibility being more and more the decisive success factors. These stakeholders are increasing creating a CSE team that consists of individuals more than ever with their own specialty and own drivers.
In addition, the time-to-market of the technology is getting shorter and is strongly dependent on the costs in the current economic climate.
All three trends converge to the manager. As a result, it is noticeable that you have to demonstrate the added value of your part in the CSE team, you must make results visible and under high pressure. How do you do that? Why is man such an important factor? What do you do with the man in your team? How do you put people in their strength and you create a work environment in which everyone comes into its own?

BRIEF BIOGRAPHY

José Carlos Quadrado is the full professor with tenure of electrical machines in the electrical engineering and automation department of the Instituto Superior de Engenharia de Lisboa (ISEL), Portugal.

Currently he holds the position of President of ISEL since 2006.

He has a BSc in Energy and Power Systems, a diploma degree in Electrical Engineering, Automation and Industrial Electronics from ISEL, a MSc and a Doctor degree in Electrical Engineering and Computers from Lisbon Technical University. He also holds the Habilitation degree (Aggregation) in Electrical Engineering from Beira Interior University.

Holds the position of President of the International Federation of Engineering Education Societies (IFEES) and the position of immediate-past president of the Ibero-American Engineering Education Association (ASIBEI), and he is also the immediate past vice-President of the European Society for Engineering Education (SEFI). Former member of the National Bologna Expert Group, he leads the Portuguese Observatory on European and Latin-American University management strategy best practices and the national association of engineering rectors and deans.

Being a member and senior member of several engineering societies and engineering education societies in several continents, he is also a visiting professor in several universities around the world and board member of technological societies.

He holds over 100 international publications (including journals and chapters of books), several patents and some international technical prizes and scholarships, and also held the position of editor and editor-in-chief in some journals. Up to now he has also developed several international engineering projects in the fields of renewable energy, fuel cells, electrical vehicles and intelligent control.

Digital Age Learning
The Changing Face of Online Education

Steve Wheeler
Plymouth Institute of Education, Plymouth University, U.K.

EXTENDED ABSTRACT

Online education was once quite simple. As a new form of distance education, it bridged the gap between those who could reach formal education and those, for whatever reason, who could not. Many institutions invested in web delivery as a primary means of engaging remote students, and a whole discourse rose up around the idea of 'online education.' It was a radical departure from the traditional correspondence courses, because it enabled instantaneous communication and feedback between students and their teachers, and allowed synchronous as well as asynchronous delivery of content. Video and live chat soon because desirable, and even essential facets of the online learning strategy. Content delivery was controlled by the experts through Learning Management Systems, and discussions were conducted via e-mail and bulletin boards. There was talk of the Virtual University, but it never really materialised. Instead, many universities adopted a blended (earlier referred to as a dual mode) delivery of their courses, which involved all of the above techniques, and a mix of other face-to-face and paper based activities. The online delivery model became a stable, reliable method for distance education for millions of students around the globe.

Then came the advent of Web 2.0 and social media and things changed, boundaries blurred and the pace of change accelerated. The rapid development of platforms and services that enabled users to both upload and download content was a departure from the previous, 'sticky' and content led approach of Web 1.0. Suddenly, in the age of the Social Web, user generated content was high profile and ubiquitous. Students began to share their own content through blogs, wikis, podcasts and videos. Platforms such as YouTube, WordPress, Blogger and Wikipedia became the first ports of call, and the user statistics grew exponentially. This was perplexing for many established online course providers. It was perplexing because they were no longer the sole arbiters of 'knowledge' and no longer held the exclusive right of mediators of learning. Many academics questioned the veracity of content that was created by 'amateurs', and many rejected that notion that knowledge could be generated, shared and repurposed freely. Issues of copyright, intellectual property and provenance became uppermost in the minds of teachers and lecturers. Many questions and much soul searching resulted:

In today’s digital age, are Learning Management Systems still required, and is e-mail now increasingly anachronistic? Students now connect on social media tools such as Facebook and Twitter and converse through mobile text. They generate their own content on a regular basis and act as the nodes of their own production. Increasingly informal collaborating comes naturally through the new tools and technologies that constitute their personal learning environments. Add to this mix the meteoric success of Massive Online Open Courses and Flipped Classrooms, the popularity of online social games and prospect of new, emerging technologies such as augmented reality and wearable systems, and we continue to question the future of our current online educational provision. Is online learning now so common place and accessible that anyone can do it? Are we reaching the point in the development of technology that we are now in danger of repeating the mistakes we made when correspondence courses led to the ignominy of 'diploma mills' and ill reputed, fake degrees? What would we need to put into place to prevent this from happening in today's knowledge economy?

In this presentation I will address many of the above questions and offer my personal views on the future of online education in the Web 2.0 digital age. I will pose several questions including: What is digital learning? How can teachers and students harness the power of tools and technologies for formal learning? What is the changing nature of knowledge? What will be the future of education, in the light of the radical changes and emerging technology? Ultimately, we will discuss issues that will impact upon all teachers and educators in the coming years: What will the next few years hold for online education? What will be the new reality for learning, knowledge and ultimately, human intelligence? Are learner expectations unfulfilled by the current provision of traditional educational institutions? How much will the roles of teachers be required to change? What new theories and practices will we need to develop to stay relevant in an increasingly technological world where the learner is taking control?

BRIEF BIOGRAPHY

Steve Wheeler is Associate Professor of Learning Technologies at Plymouth University, in South West England. Originally trained as a psychologist, he has spent his entire career working in media, technology and learning, predominantly in nurse education (NHS 1981-1995) and teacher education (1976-1981 and 1995-present). He is now in the School of Education, at the Faculty of Health, Education and Society.

Steve teaches on a number of undergraduate and post-graduate teacher education programmes in the UK and overseas. He researches into e-learning and distance education, with particular emphasis on the pedagogy underlying the use of social media and Web 2.0 tools, and he also has research interests in mobile learning and cyber-cultures. Steve is regularly invited to speak about his work and has given keynotes and invited lectures to audiences in 30 countries across 5 continents. He is currently involved in several research programmes related to e-learning, social media and handheld technologies.

Steve is the author of more than 150 scholarly articles, with over 2500 academic citations and is an active and prolific edublogger. His blog Learning with 'e's is a regular online commentary on the social and cultural impact of disruptive technologies, and the application of digital media in education and training. It currently attracts in excess of 150,000 views each month.

Steve is chair of the Plymouth e-Learning Conference, and between 2008-2011 was also co-editor of the journal Interactive Learning Environments. He serves on the editorial boards of a number of learning technology and education related open access academic journals including Research in Learning Technology (formerly ALT-J), the International Review of Research in Open and Distance Learning (IRRODL), the European Journal of Open, Distance and eLearning (EURODL) and Digital Culture and Education. He has served on the organising and executive committees of a number of international academic conferences, including ALT-C, ICL, EDEN, IFIP and AICT.

In 2008 Steve was awarded a Fellowship by the European Distance and E-learning Network (EDEN), and in 2011 he was elected to serve as a member of the Steering group of EDEN's Network of Academics and Professionals (NAP). Between 2008-2013 he also served as chair of the influential worldwide research group IFIP Technical Committee Working Group 3.6 (distance education) and is author of several books including The Digital Classroom (Routledge: 2008) and Connected Minds, Emerging Cultures (Information Age: 2009). He lives in Plymouth, on the South West coast of England.

Mathematics Teaching
Is the Future Syncretic?

Larissa Fradkin
London South Bank University, Brunel University and Sound Mathematics Ltd., U.K.

EXTENDEND ABSTRACT

Teaching is one of the oldest professions on Earth and mathematics teaching must have had come first, since it appears that numbers had been invented before letters! Yet "mathematics wars" have been raging throughout the XX century and technology has only added fuel to fire: should mathematics be taught as poetry, requiring an inordinate amount of memorising and practising or should teachers concentrate on abstract concepts, with the tedium of calculations left to calculators and computers? Can ordinary learners grasp abstract concepts at all? On top of that, a modern University maths teacher teaching STEM students, particularly, future engineers has to cope with large classes, much larger than most European teachers had to deal with in the past. Can any of the teaching approaches be implemented in such environment in an effective manner? The advent of the XXI century saw mathematics teachers cajoled into employing the "evidence-based" technological solutions that had been shown to work when training University administrators, business managers or technicians. Many resisted, arguing that maths learning is a different process to learning a few words and procedures. Now it is all about Massive Online Open Courses and Flipped Classrooms. Can ordinary engineering students learn mathematics by watching MIT or Khan Academy videos? Can ordinary mathematics teachers facilitate the process by "flipping" in an effective way? I will present my thoughts on the subject, argue against false dichotomies and suggest syncretic solutions, including the ones that rely on cognitive technologies of the future.

I will start discussing several myths that became popular among educationalists:

Only what students discover for themselves is truly learned, while in reality students learn in a variety of ways. Recent research has shown that basing most learning on student discovery is time-consuming, does not insure that students end up learning the right concepts, and can delay or prevent progression to the next level. Successful programs use discovery for only a few very carefully selected topics, never all topics.

There are two separate and distinct ways to teach mathematics,… conceptual understanding through a problem solving approach and through drill and kill, while according to many experts success in mathematics needs to be grounded in well-learned algorithms as well as understanding of the concepts.

*Math concepts are best understood and mastered when presented "in context"; in that way, the underlying math concept will follow automatically, even though it has been repeatedly shown that w*hen story problems take centre stage, the math it leads to is often not practiced or applied widely enough for students to learn how to apply the concept to other problems.

I will move to recent MOOCs data that show that the pass rates of current MOOCs registrants are low and the overwhelming majority of those who obtain the certificate of achievement already have a degree. I will suggest my answers to the question posed by these data "What are MOOCs missing?" I will suggest that they open a door to advanced cognitive tutors that employ the oldest and best teaching method – Socratic dialogue, which allow students to master abstract concepts and practice under "expert supervision" at the time and place of their choosing.

Finally, I will address the suggestion that because of MOOCs in 50 years there will be only 10 institutions in the world delivering higher education. However, I would argue – in line with many other academics – that, particularly in the first year of their academic studies, students, disadvantaged STEM students need intensive guided teaching. This

can be delivered only in person and only by the most experienced teachers capable of not just "talking" – delivering content, but mainly of "listening" – and readjusting their delivery depending on the student immediate feedback. Of course, these experienced teachers and their students would benefit from access to quality MOOCs.

BRIEF BIOGRAPHY

Larissa Fradkin is Emerita Professor, London South Bank University, UK and Associated Professor, Brunel University, UK. Trained as a physicist at St Petersburg University, Russia, from 1974 till 1977 she studied for her PhD in Applied Mathematics at Victoria University of Wellington, New Zealand. From 1978 till 1984 she was employed as a Research Scientist at the NZ Department of Scientific and Industrial Research and from 1985 till 1992, as a Research Associate at the Department of Applied Mathematics and Theoretical Physics of Cambridge University, UK. From 1993 till 2009 Larissa was a member of academic staff at London South Bank University where she created and ran a Research Group on Mathematical Modelling of Ultrasonic NDE (Non-Destructive Evaluation of industrial components and materials) and teaching mathematics on various engineering courses. She is now a Managing Director of an independent research organisation Sound Mathematics Ltd., working on her ultrasonic projects, mainly in collaboration with CEA (the French Atomic Commission) and promoting sound mathematics education of engineers. Larissa is a Fellow of IMA (UK Institute for Mathematics and Its Applications), IOP (UK Institute of Physics) and IET (UK Institute of Engineering and Technology). Larisa has authored and co-authored over a 100 scientific and scholarly publications, lately on pedagogy behind her system of maths teaching and in 2013 Bookboon has published her open access e-textbook "College Algebra and Calculus: The Whys and Hows." Larissa has been a member of organising committees of several international engineering conferences and is currently a UK National contact person for SEFI's Maths Working Group (SEFI is the European Society for Engineering Education) and a member of the Committee on Mathematical Education for Engineers, iNEER (International Network for Engineering Education and Research).
Larissa lives in Cambridge, England.

Team Learning in Engineering Education

Erik de Graaff
Aalborg University, Denmark

Abstract: Most engineers work in teams during their professional life. Hence, learning to be an effective team member is an essential aspect of preparing for engineering practice. This presentation will analyse how Problem Based Learning (PBL) supports students in engineering in developing teamwork skills, like leadership, communication skills, and the ability to correctly assess your own contribution to the teamwork. Several tools that support this process will be discussed.

BRIEF BIOGRAPHY

Erik de Graaff is trained as psychologist and holds a PhD in social sciences. He has been working with Problem Based learning (PBL) in Maastricht from 1979 till 1990. In 1994 he was appointed as associate professor in the field of educational innovation at the Faculty of Technology Policy and Management of Delft University of Technology. Dr. de Graaff has been a visiting professor at the University of Newcastle, Australia in 1995 and a guest professor at Aalborg University in Denmark. The collaboration with Aalborg University led to an appointment as full professor at the department of Development and Planning in 2011. Dr. de Graaff is recognized as an international expert on PBL. He contributed to the promotion of knowledge and understanding of higher engineering education with numerous publications and through active participation in professional organizations like SEFI, IGIP, IFEES and ALE. He has published over 200 articles and papers and he has presented more than 70 keynotes and invited lectures on various topics related to PBL in higher education, like: Working with PBL, Management of change, Assessment and evaluation, Methods of applied research and Collaboration between university and industry. Since January 2008 he is Editor-in-Chief of the European Journal of Engineering Education.

INFORMATION TECHNOLOGIES SUPPORTING LEARNING

FULL PAPERS

Wiki-mediated Collaborative Writing in Teacher Education

Assessing Three Years of Experiences and Influencing Factors

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Keywords: Action Category, Collaborative Learning, Collaborative Writing, MediaWiki, Taxonomy, Wiki.

Abstract: Wikis have been reported as tools that promote collaborative writing in educational settings. Examples of wikis in teacher education are group projects, glossary creation, teacher evaluation, and document review. However, in spite of studies that report on successful stories, the claim that wikis support collaborative writing has not yet been firmly confirmed in real educational settings. Most studies are limited to participants' subjective perceptions, and do not take into account influencing factors, or the relationships between wikis and the learning environment. In this paper, students' collaborative writing activities over a period of three years are investigated using a taxonomy of action categories and the wiki data log that tracks all students' actions. The paper analyses the level of contribution of each member of student groups, the types of actions that the groups carried out on the wikis, and the timing of contribution. The article also discusses personal and contextual factors that may influence collaborative writing activities in teacher education, and recommendations for students as well.

1 INTRODUCTION

Wikis have been used in teacher education to achieve varied educational goals, such as teacher evaluation, document assessment, or student projects. Research studies point out to the potentialities of wikis to support collaborative work (Minocha and Thomas, 2007; Thomas et al., 2009). However, in spite of positive experiences that have been reported in the literature (Kuteeva, 2011; Naismith et al., 2011), a number of researchers are more circumspect about the potentialities of wikis to support collaborative learning and writing. Several hypotheses have been raised to explain the low level of collaboration when using wikis: unfamiliarity with wikis, lack of experience, dominant learning paradigm, limited student contribution, reluctance and resistance to use wiki, lack of motivation and engagement, time management, problem of ownership, and lack of appropriate pedagogy (Cole, 2009; Grant, 2009; Elgort et al., 2008; Judd et al., 2010; Karasavvidis, 2010).

To further explore these hypotheses, this article reports on a small-scale empirical study in teacher education that examined the extent to which students collaborated to perform wiki-based tasks associated with collaborative writing over a period of three years. The work uses the wiki data log (or history log), and a taxonomy of action categories to investigate the value of wiki-mediated collaborative writing. In addition, influencing factors that may impact collaborative writing with wikis are discussed, including some recommendations to help students engage in collaboration.

The article is structured as follows. First, the relationship between wiki technology and collaborative writing is clarified. Second, related research work is reported. The next section describes the theoretical framework, followed by the methodology of the work. Then, the results and discussion are presented. Finally, some remarks conclude the article.

2 WIKI-MEDIATED COLLABORATIVE WRITING

2.1 Wiki Technology

This work used one of the most popular wiki platforms – MediaWiki - to perform collaborative writing activities (Kasemvilas and Olfman, 2009). MediaWiki uses a simplified HTML language and provides an extensive functionality for user authentication, making it appropriate for educational purposes (Su and Beaumont, 2010). Another important functionality of MediaWiki is the history log that keeps track of students' actions by name, date, and colour coding (Lund and Smørdal, 2006). In addition, MediaWiki provides a discussion page for communication, reflections and negotiations.

2.2 Wiki and Collaborative Writing

Collaborative writing is an activity that enables participants to produce a text collectively (Witney and Smallbone, 2011). It is grounded in the social-constructivist learning theory (Vygotsky, 1978), and assumes that participants can achieve more in terms of learning benefits than individuals. Collaborative writing is opposed to simply splitting up the task, work independently of each other, and then assemble individual contributions to a final product. This activity is called cooperation rather than collaboration (Scanlon, 2000, cited in Judd, Kennedy and Cropper, 2010).

Wikis provide a space for collaborative writing by means of a simple interface allowing students to share information, discuss, negotiate, and produce a text by more than one author. Wiki-mediated collaborative writing is a coordinated activity that enables students to edit and revise each other's contribution to the wiki task (Chao and Lo, 2011; Meishar-Tal and Gorsky, 2010; Trentin, 2009; Witney and Smallbone, 2011).

3 THEORETICAL PERSPECTIVE

The underlying theoretical perspective of this research relies on a taxonomy developed by Pfeil, Zaphiris and Ang (2006). It is used to classify and analyse students' actions carried on the wiki. The taxonomy included originally 13 actions, of which the following 10 were identified as important for this work (Ibid, p. 101):

- *Add Information (or content)* - Addition of topic-related information
- *Add Link* - Addition of links or linking of a word within an existing sentence to a page
- *Clarify Information (or content)* - Rewording of existing information without adding new information. Rewording done in order to clarify the content
- *Delete Information (or content)* - Deletion of topic-related information.
- *Delete Link* - Deletion of links or removal of the linking function from a word within a sentence
- *Fix Link* - Modification of an existing link
- *Format* - Changes that affect the appearance or structure of the page
- *Grammar* - Alterations of the grammar
- *Spelling* - Correction of spelling mistakes
- *Style/typography* - Activities that affect the presentation of the text

To measure the degree of collaboration, these actions can be classified from the lowest level of collaboration (that is cooperation as defined above) to the highest level of collaboration. Between these levels, a wide range of actions can be stated. The lowest level of collaboration is performed when students only add content/link, delete content/link within their own subtask. A high level of collaboration is achieved when students rephrase each other's work, clarify and modify the content of the wiki, and correct the grammar and spelling. In addition to rewording and clarifying content as defined in the taxonomy, students can make peers aware of changes and ask them to react to them. These activities can provide a high level of collaborative writing. Between these forms, varied level of collaboration can be achieved, for example when students clarify the meaning of other's work, add content and links to already existing pages, structure some other's work by moving sentences. As a result, some actions may be considered as more cooperative than collaborative activities, while other activities may be classified as more collaborative than cooperative, as defined above.

4 RELATED WORK

Wiki-mediated collaborative writing can be studied from different perspectives and methods. A literature review reveals that most studies use qualitative methods such as interviews and quantitative methods such as survey questionnaires to investigate participants' perceptions of collaborative writing.

In recent years, a growing number of studies have drawn on the wiki data log, also called history function that tracks all students' actions being made on the wiki. The history log is inherently more reliable to analyse students' collaborative writing activities than perceptions-based studies. This work is a continuation and a synthesis of a research that started in 2010 in the field of wiki-mediated collaborative writing over a period of three years (Hadjerrouit, 2011; Hadjerrouit, 2012a, Hadjerrouit, 2012b; Hadjerrouit, 2013a, Hadjerrouit, 2013b). This previous work used both the wiki data log and the taxonomy described in the theoretical perspective. A similar work was done by Judd, Kennedy, and Cropper (2010), who analysed data that are automatically recorded in the history log to assess the nature and scope of users' contributions. They found little evidence of collaborative writing among participants, and that many students' contributions were superficial. Likewise, Leung and Chu (2009) reported that students worked individually most of the time, and edited each other's contributions if necessary. In some contrast, Meishar-Tal and Gorsky (2010) indicated that adding text was carried by a large majority of students, but the percentage of editorial changes was higher than adding sentences, because the students were required to edit each other's work. Nevertheless, most of the work based on the wiki data log pointed out that wikis do not automatically make collaboration happen due to a number of influencing factors in the teaching and learning environment.

5 METHODOLOGY

5.1 Research Goal and Questions

This work aims at exploring the extent to which students collaborated to perform wiki-based tasks associated with collaborative writing in teacher education. Relying on the taxonomy described in the theoretical perspective and the history log that tracks all students' contributions to the wikis, this work attempts to address three questions:

1. What is the level of work contribution of each member of the student groups?
2. What are the types of actions that the groups carried out on the wikis?
3. What are the time intervals and timing of contributions of the groups?

5.2 Participants

The experiments over a three-year period were based on three cohorts of participants. The participative students were enrolled in a Web 2.0 technology course that was offered each year. None of the students experienced wiki-based collaborative writing before taking the course. Some students possessed good technical skills, while other had background in pedagogy and learning paradigms. The first experiment lasted for a whole semester from January to May 2010, while the following experiments in 2011 and 2012 lasted for eight weeks. The number of participants in 2010 was 8 students, divided into 3 groups of 2-4 students. In 2011, the number of participants was 10, divided into 3 groups of 3-4 students. The number of participants in 2012 increased in comparison with previous experiments. Sixteen students, divided into 6 groups of 2-4, were enrolled in 2012. Despite these differences, the conditions under which the experiments were carried out were basically similar. Each experiment started with new writing tasks, but the students were encouraged to study previous editions of the course.

5.3 Writing Tasks

The wiki writing tasks were situated within teacher education, including topics within mathematics, science, geography, history, and other subjects. The specificities and technical features of wikis were introduced to the students during the first week of the course. Lectures on collaborative writing were given in the following two weeks. The students were required to submit their wikis for continuous evaluation on the basis of the following criteria. First, the wikis should follow general usability criteria such as good technical layout, clear linking and navigation. Second, the wikis must contain information of good quality, without linguistic, grammar, and spelling errors. Third, the content of the wiki should draw on recent curricular development in teacher education, and include well-structured study material with images, figures, tables, lists, and references. Fourth, the wikis should be self-explaining, and provide information that is relevant to the target audience. Fifth, the wikis should contain a minimum of 4000 words to ensure that a sufficient quantity of writing is produced. Sixth, the students are required to edit each other's contributions, and take actively part in discussion of the wiki content and structure. Finally, in line with the wiki philosophy based on collaborations, the students were not assessed individually, but as a group working collaboratively. Nevertheless, the history log can be used to look at the students' individual contributions to the wikis.

5.4 Data Collection and Analysis Methods

In an attempt to provide a consistent evaluation of the experiments, this work used the wiki data log to collect three types of quantitative data. Firstly, the level of work distribution among members of the student groups to assess the amount of work and frequency produced by each student.

Secondly, the total number of actions per group and category of the taxonomy described in the theoretical perspective, including their frequencies, were collected and analysed, such as whether an action was an addition, deletion or clarification of content, addition, deletion, or fixation of a link, formatting, spelling, style, or grammar.

Then, information on work intervals and timing of contribution were recorded to assess the amount of work produced by the students over a period of three years.

Finally, observations and informal discussions were used to gain supplementary information on students' collaborative writing activities.

6 RESULTS

The results are described with respect to the experiments that were carried out in 2010, 2011, and 2012. The results are reported in terms of level of distribution, types of actions, and time intervals.

6.1 Level of Work Distribution

Table 1 (Appendix) presents the distribution of work made by each member of the student groups over a period of three years (2010-2012).

In 2010, the percentage of contributions ranged from 39.56% to 16.40% of total activities. One student in group 1 contributed to almost 40% of the work, and the rest was distributed among the other students. In group 2, one student contributed to 87.43%. The same situation occurred in group 3, where one student contributed to 70.05%.

In 2011, two students in group 3 contributed to 82.53%. In group 2, one student made 46.48% of all contributions. In contrast, the work was more equally distributed in group 1 than in the other groups.

In 2012, a similar distribution of work can be observed. One student did most of the work in groups 4, 5, and 6. Two students in group 2 and 3 contributed to more than 80% of the work. The work contribution of group 1 was evenly distributed for three students, with the exception of one student (student 4).

Table 1 (Appendix) enables to see the level of contribution made by each student in the respective groups. The table does neither indicate the types of actions or activities performed by the students, nor show the level of collaboration among students. Thus, further analysis is required to gain more insight into the level of collaborative writing among the students and the types of actions performed on the wikis.

6.2 Type of Actions

The analysis of the results shows that the students carried out all editing actions described in the taxonomy for collaborative writing (add, modify, and delete content; add, fix, and delete link; format, and grammar, style, and spelling) to a certain extent.

Table 2 (Appendix) shows all editing actions over a period of three years (2010-2012). Note that grammar, style, and spelling are put together, because these actions are somehow similar. They aim at correcting grammar mistakes and spelling, changing the style, typography, and presentation of the wiki content. These actions may then be considered as collaborative actions, though to a lesser degree than clarifying content, especially when students contribute to each other's work.

The most frequent action in 2010 was formatting (43.90%), followed by add content (18.47%), clarify content (12.89%), add link (9.99%), delete content (8.17%), fix link (3.09%), grammar/style/spelling (2.84%), and delete link (0.65%).

In 2011, the most frequent action was add content (28.27%), followed by formatting (20.66%), add link (17.72%), grammar/style/spelling (12.08%), delete content (8.30%), clarify content (7.49%), fix link (3.81%), and delete link (1.67%).

In 2012, the most important action was formatting (23.39%), followed by add content (20.62%), add link (17.68%), clarify content (12.04%), grammar/style/spelling (8.59%), fix link (7.73%), delete content (7.25%), and delete link (2.70%).

The average result achieved for the three-year period was a follows. The most frequent action was formatting (29.32%), followed by add content (22.45%), add link (15.13%), clarify content (10.81%), delete content (7.91%), grammar/style/spelling (7.84%), fix link (4.87%), and delete link (1.67%). A total of 7304 actions were performed, and only 853 actions (10.81%) aimed at genuine collaboration (Table 2, Appendix). If grammar/style/spelling (456 actions, 7.84%) are considered as collaborative actions, then the total number of actions that aimed at collaboration is 1309, that is 18.65% of all actions.

Hence, it appears that cooperation is more evident that collaboration and that no significant progress has been made from 2010 to 2012 regarding the action "modify content" (average score 10.81%). The action started with 12.89%, decreased in 2011 (7.49%), and increased in 2012 (12.04%). Formatting (29.32%) and add content (22.45%) were the most important activities over three years, in contrast to clarify content and grammar/style/spelling. The evolution of students groups' actions over three years confirms the results (See Figure 1 in the Appendix).

Summarizing, it is obvious that students were more apt to engage in cooperation rather than collaboration. Group members mostly worked on individual sections of the wikis. This reduced their ability to produce shared knowledge and collective documents of the wiki tasks. There were few occasions when the groups worked on the same section of the wiki by revising substantially each other's work. Clearly, this cannot be considered as genuine collaborative writing, since students rarely revised or modified each other's content. Instead, students were more concerned with formatting, adding content, formatting the text, and adding links.

6.3 Timing of Contribution

Table 3 (Appendix) shows the timing of contributions and work intervals over a period of three years, including the average number of actions per week. Note that in 2011 and 2012, the workload for the month of March was distributed over two weeks, which means that the average number of actions per week must be divided by 2, and not by 4 as it is the case for the month of May in 2010.

In 2010, Table 3 shows that all groups worked much as the last deadline approached, and did not follow the schedule assigned throughout the experiment period from January, 19 to May, 14. This was particularly true for group 1 (G1) and group 3 (G3).

In 2011, a similar tendency was observed, particularly for group 2 (G2) and group 3 (G3), in stark contrast to group 1 (G1). Also here the average number of actions performed in March was much higher than in February and January. This was also the case in 2012, though to a lesser degree.

As a result, it seems that a slight progression has occurred from 2010 to 2012 since the amount of work has not increased drastically the last month in 2012 in comparison to 2011, which itself achieved a better result than 2010. This, however, does not automatically mean that students collaborated. It is more likely that they cooperated as a triangulation of the timing of contribution seems to indicate.

7 DISCUSSION

A cross-checking of the results shows that the students did not collaborate much in their attempt to perform writing tasks. A number of influencing factors may explain the low level of collaboration. These may be classified in two broad categories: Contextual and personal factors.

Contextual factors are those related to the teacher, technology, assessment procedures, and learning paradigm.

Personal factors are students' motivation, prior knowledge in collaborative writing, and familiarity with wiki technology.

In addition to influencing factors, some recommendations are suggested to improve collaborative writing with wikis.

7.1 Contextual Factors

According to Karasavvidis (2010), the learning paradigm in higher education is based more on the behaviourist paradigm than collaborative learning. Hence, wiki-mediated collaborative writing may be inhibited when it is introduced into educational settings where traditional views of learning such as behaviouristic practices are actually predominant. As a result, students without sufficient collaborative skills may be disadvantaged even though collaborative writing is potentially possible with wiki technology.

Another factor that may have influenced students' collaborative writing activities is the assessment procedure used to evaluate students' contributions to the wikis. Since students were assessed as groups, and not according to their individual contributions, it is not surprising that some students did not fully engage in collaborative writing. As a result, most of the work was done by some students as the distribution of work clearly reveals. It is also possible that some students were more dominant than others (Meishar-Tal & Gorsky, 2010). Clearly, collaborative writing requires more group assessment, because it may be necessary to judge individual contributions, which in turn, may influence positively students' contributions to collaborative writing.

The third factor is the wiki technology being used, that is MediaWiki. While the technology is based on an interface with a simplified HTML language, it does not offer an advanced WYSIWYG editor, which may facilitate the use of wikis. In addition, the discussion page is not good enough to promote reflections on collaborative writing, influencing thereby students' activities performed on the wikis.

7.2 Personal Factors

The first category of personal factors comprises perceptions that students hold about wikis, familiarity with the tool being used, its limitations and potentialities for collaborative writing (Caple and Bogle, 2013; Minocha and Thomas, 2007). Informal discussions and observations revealed that some students without technical background were not always comfortable with wikis. On the other hand, students with solid background in information technologies were more confident with using wikis. While students did not feel that they had to know everything about wikis, they did not deny the importance of the need to familiarize themselves with wikis to the extent of knowing what their functionalities and features are and how to use them for developing wikis. Some students believed that pre-work and preparation for wiki use before entering collaborative writing would have helped them to tackle some technical problems.

The second personal factor is the students' lack of collaborative skills and experience in collaborative learning. Such skills are indeed necessary to foster collaborative learning, which is a prerequisite for collaborative writing. Hence, collaborative learning should not be limited to wikis alone but should be possible using any means found useful, for example let students work together and discuss a topic that can add to each other's knowledge (Tetard et al., 2009).

Another critical factor of success is the students' motivation to effectively engage in meaningful collaborative writing (Hadjerrouit, 2013a). Motivation - as a personal factor - is an essential component of collaborative writing with wikis. Observations and informal discussions revealed that motivated students edited more content and used more wiki features. It seems that motivation is closely related to the wiki task itself, whether it is relevant and meaningful to the student.

7.3 Recommendations

Based on the results and influencing factors, some recommendations are suggested to help students engage in genuine collaborative writing using wiki technology.

Firstly, students need to familiarize themselves with wiki technology, because not all students possess sufficient pre-requisite knowledge for using wikis. Hence, technical training is still needed to help students acquire the basic knowledge that is necessary to use wikis for collaborative writing.

Secondly, wiki technology should be improved to include a WYSIWYG editor and additional features that facilitate collaborative writing. Likewise, the discussion page of existing wiki tools is not good enough to support genuine communication. It should be improved, and used in conjunction with other Web 2.0 technologies, such as Google Talk and Twitter, but also other communication technologies such as mobile phone, Skype, and emails.

Another recommendation that may foster collaborative writing is the students' preparation and prior acquisition of basic collaborative skills (Minocha and Thomas, 2007). Students should have a sense of how collaboration can be achieved by following a common goal and coordinating their efforts under the guidance of the teacher.

Then, in terms of wiki content, student groups need to be knowledgeable in the topics being studied in order to create wikis of good quality with relevant references, because those lacking basic knowledge in the topic being studied will not be able to truly contribute to the wiki content. In addition, students should possess some language proficiency to make the writing process easier, especially for those with technical background (Li and Zhu, 2013).

Furthermore, collaborative writing needs to benefit from clear assessment procedures and criteria. These may include both peer-assessment and self-assessment, on individual or group basis. To be effective, assessment of students' contributions to the wiki should be mandatory, and based on pre-established quality criteria.

Finally, the process of creating wikis needs to be carefully planned by teachers to guide and sustain students' collaborative writing activities. In addition, to management and planning activities, wiki-based collaborative writing cannot be successful without a sound pedagogy based on collaborative learning or similar learning paradigms such as the sociocultural approach to learning (Vygotsky, 1978). A pedagogical strategy that supports genuine collaborative writing should engage students in collaborative work and group dynamics to a greater benefit for the students.

8 CONCLUSIONS

Wikis have the potential to foster collaborative writing in teacher education, but wiki-mediated collaborative writing is a demanding task that requires pedagogical changes. These are however difficult to achieve mainly because contextual and personal factors, which can act as barriers to learning, can prevent teacher students from collaborating. Even if it is impossible to draw any general conclusions from the experiments that were performed in 2010, 2011, and 2012, it can be ascertained that students did not make a real progress in their attempt to collaborate. To exploit the full potential of wikis in future experiments, it is important to guide students into all aspects of wiki-based collaboration. This entails taking into consideration both contextual and personal factors, affecting collaborative writing with wikis, and the suggested recommendations as well. Moreover, progress in wiki-based collaborative writing can be achieved through the iterative and continuous cycle of experimentations and evaluations in varied teacher education contexts.

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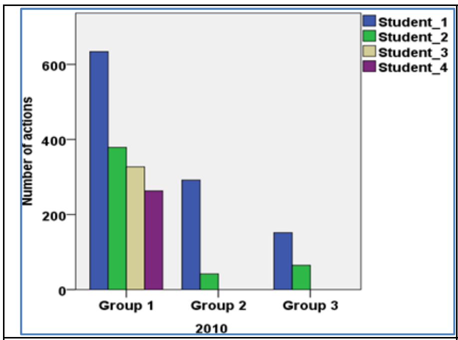
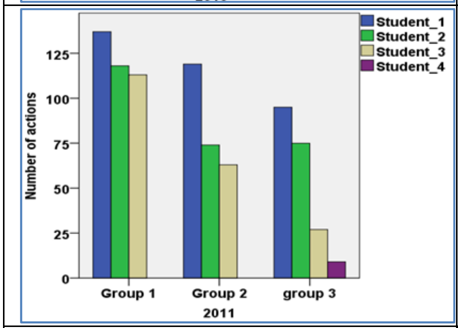
APPENDIX

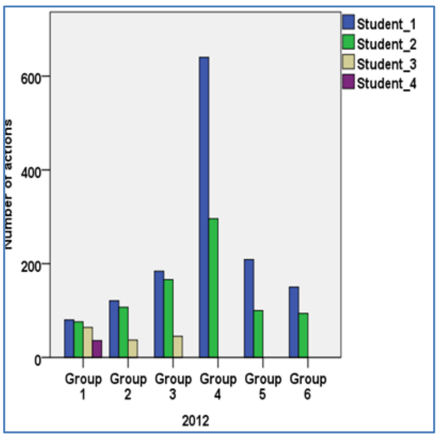
Table 1: Students' work load and distribution (2010-2012).



2010			
	Group 1	**Group 2**	**Group 3**
Student 1	634 (39.56%)	292 (87.43%)	152 (70.05%)
Student 2	379 (23.64%)	42 (12.57%)	65 (29.95%)
Student 3	327 (20.40%)	…	…
Student 4	263 (16.40%)	…	…
Total	**1603 (100%)**	**334 (100%)**	**217 (100%)**



2011			
	Group 1	**Group 2**	**Group 3**
Student 1	137 (37.23%)	119 (46.48%)	95 (46.12%)
Student 2	118 (32.07%)	74 (28.91%)	75 (36.41%)
Student 3	113 (30.70%)	63 (24.61%)	27 (13.10%)
Student 4	…	…	9 (4.37%)
Total	**368 (100%)**	**256 (100%)**	**206 (100%)**

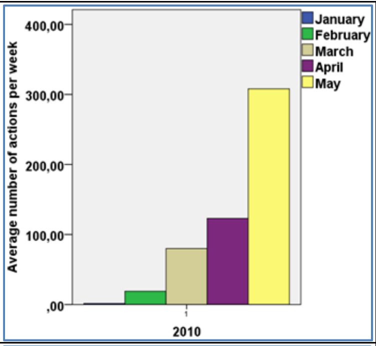


2012			
	Group 1	**Group 2**	**Group 3**
Student 1	80 (31.25%)	121 (45.66%)	184 (46.58%)
Student 2	76 (29.68%)	107 (40.37%)	166 (42.02%)
Student 3	64 (25.00%)	37 (13.96%)	45 (11.39%)
Student 4	36 (14.06%)	…	…
Total	**256 (100%)**	**265 (100%)**	**395 (100%)**
	Group 4	**Group 5**	**Group 6**
Student 1	640 (68.37%)	209 (67.63%)	150 (61.47%)
Student 2	296 (32.95%)	100 (32.36%)	94 (38.52%)
Total	**936 (100%)**	**309 (100%)**	**244 (100%)**

Table 2: Number and frequency of actions (2010-2012).

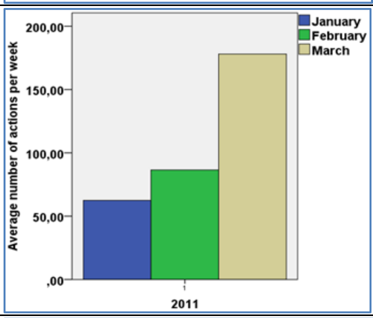
	Total 2010	Frequency 2010 (%)	Total 2011	Frequency 2011 (%)	Total 2012	Frequency 2012 (%)	Total 2010-2012	Frequency 2010-2012 (%)
Clarify content	418	12.89%	91	7.49%	344	12.04%	853	10.81%
Delete content	265	8.17%	96	8.30%	207	7.25%	568	7.91%
Add content	599	18.47%	309	28.27%	589	20.62%	1497	22.45%
Fix link	100	3.09%	33	3.81%	221	7.73%	354	4.87%
Delete link	21	0.65%	21	1.67%	207	2.70%	249	1.67%
Add link	324	9.99%	178	17.72%	505	17.68%	1007	15.13%
Grammar, style, spelling	92	2.84%	119	12.08%	245	8.59%	456	7.84%
Formatting	1424	43.90%	228	20.66%	668	23.39%	2320	29.32%
Total actions	3243	100%	1075	100%	2986	100%	7304	100%

Table 3: Average number of actions per week (2010-2012).



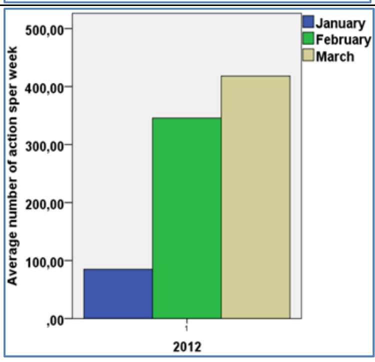
2010

	G 1	G 2	G 3	Average no. of actions per week
January (2 weeks)	2	1	0	1.5
February (4 weeks)	26	31	19	19
March (4 weeks)	247	43	30	80
April (4 weeks)	323	55	114	123
May (4 weeks)	966	94	172	308
Total	1564	224	335	106.3



2011

	G1	G 2	G 3	Average no. of actions per week
January (2 weeks)	91	30	4	62.5
February (4 weeks)	187	97	62	86.5
March (2 weeks)	87	129	140	178
Total	365	256	206	109



2012

	G 1	G 2	G 3	G 4	G 5	G 6	Average no. of actions per week
January (2 weeks)	155	11	0	3	0	1	85
February (4 weeks)	490	207	128	240	148	178	347.75
March (2 weeks)	291	173	116	21	156	79	418
Total	936	391	244	264	304	258	283.58

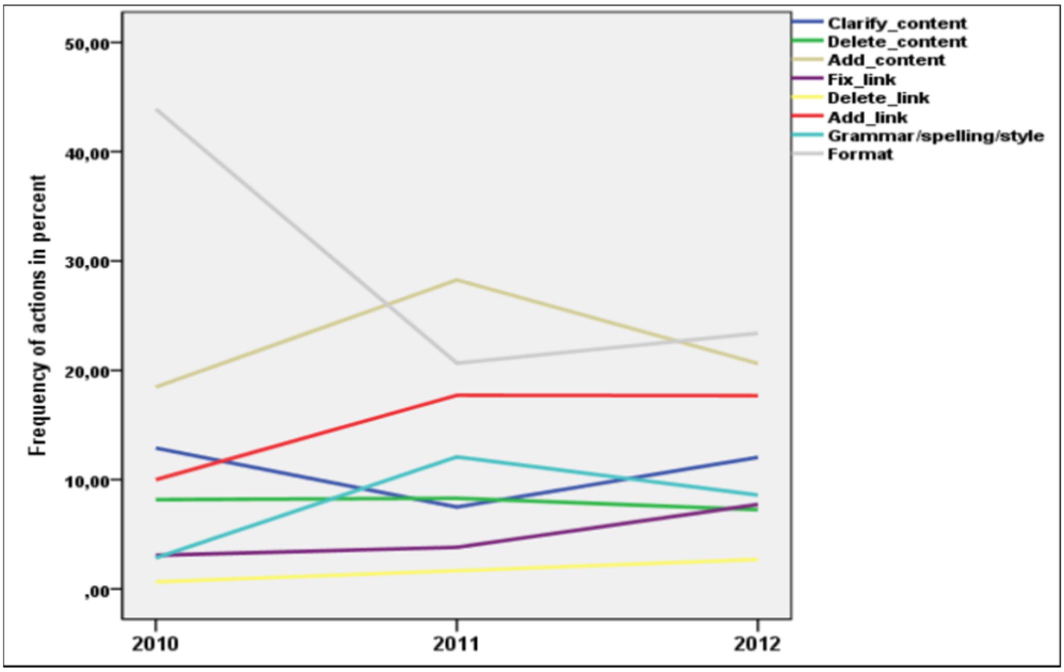


Figure 1: Evolution of student groups' actions (2010-2012).

Overcoming Cultural Distance in Social OER Environments

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Keywords: Barriers, Culture, TEL, Cultural Distance, Social Software, OER.

Abstract: Open educational resources (OERs) provide opportunities as enablers of societal development, but they also create new challenges. From the perspective of content providers and educational institutions, particularly, cultural and context-related challenges emerge. Even though barriers regarding large-scale adoption of OERs are widely discussed, empirical evidence for determining challenges in relation to particular contexts is still rare. Such context-specific barriers generally can jeopardize the acceptance of OERs and, in particular, social OER environments. We conducted a large-scale (N = 855) cross-European investigation in the school context to determine how teachers and learners perceive cultural distance as a barrier against the use of social OER environments. The findings indicate how nationality and age of the respondents are strong predictors of cultural distance barrier. The study concludes with identification of context-sensitive interventions for overcoming the related barriers. These consequences are vital for OER initiatives and educational institutions for aligning their efforts on OER.

1 INTRODUCTION

Open educational resources (OERs) and practices to increase the sharing behavior of both educators and learners have been widely discussed in the domain of technology-enhanced learning (TEL) in the recent years. Online OER environments have been receiving attention because they serve as platforms for educators and learners to search and collaborate in. While many initiatives have been rather successful in keeping their OER environments in linear growth with increased amounts of published learning objects (Ochoa, 2009), maintaining active participation in and use of the OER environments remains the key challenge (Chen, 2010; D'Antoni 2008; Yuan et al., 2008). Existing research has been discussing various barriers that hinder or negatively affect OER adoption and use in teaching and learning activities. Such barriers relate to lack of awareness of OER and related copyright and intellectual property issues (Chen, 2010; Yuan et al., 2008; Hatakka, 2009), Institutional regulations and restrictions (Yuan et al., 2008; Hatakka, 2009), quality of resources (Hatakka, 2009; Richter & Ehlers, 2011), and so on. As indicated by Chen (2010) and Hatakka (2009), not all challenges become significant, and barriers can be highly context-dependent. Therefore, many challenges could occur depending on the types of educational practices in the region or country and depending on the background, experiences, and perceptions of the educators and learners. One of the crucial topics for OER is cultural distance. As depicted by Hatakka (2009), cultural expressions also pose a challenge for understanding where language plays a strong role in inhibiting factors of OER.

The OER movement must consider the implications of knowledge sharing carefully, as many initiatives are basing their OER services and environments on social software-like functionalities that place educators and learners as key users to share, discuss, and collaboratively work on OERs (Ha et al., 2011; Sotiriou et al., 2013). Knowledge sharing is implying, in this case, not only sharing of OER but also the collaborative practices around the resources. The established connection between social software and OERs to social OER environments can have multiple potentials. As indicated by research on social software in provision of teaching and in pedagogy, these services can provide positive learning outcomes and intriguing experiences for both educators and learners when applied to teaching practices (Hall & Davison, 2007;

Wever et al., 2007). However, the connection to OER places educators even more in a key role in OER environments with a strong focus on functionalities for networking and collaboration. Such environments build on international educator and even learner communities, providing materials across subject areas of the curriculum in various languages. As elaborated by Lai and Chen (2011) and Zhang (2010), adoption of specific social software services might be highly country dependent because of differences in culture and context. As argued by Agarwal (2007), there are various challenges to knowledge sharing while so-called cultural distance becomes highly important in a context where people deal within online social environments. The finding is in line with the studies of Noll et al. (2010) and Pallot et al. (2010) that deal with collaboration across distance. However, the current literature has been very limited in studies that could inform the domain regarding how strong those cultural barriers are perceived across nations, within educator and learner communities that adopt these social OER environments. Such information is necessary for any educational institution or educator evaluating the suitability of the OER environments to own purposes. This information is also vital for OER providers to understand the barriers for their end users and the circumstances around those challenges.

We address this gap by the means of a large-size exploratory study (N = 855) to inspect how strongly cultural distance barrier is perceived by teachers and learners in primary and secondary schools across Europe. Within our inspection, the aim is not to define culture or different types of influencing factors for it. However, we aim to understand in a cross-national view to what extent teachers and learners perceive cultural distance when dealing with OER online social environments. In addition to observing the barriers of cultural distance, our study strives to understand possibilities to overcome such barriers. These interventions are discussed on a technical and nontechnical level to describe the possibilities for OER content and technology providers as well as educational institutions.

The structure of the paper is as follows. The next section describes the theoretical background for culture and social software focused OER. Then, we will describe the methodology for the study. The results are presented in the fourth section, followed by the discussion of the results. The paper concludes by describing the limitations of this study as well as the key contributions to both research and practice.

2 THEORETICAL BACKGROUND

OER has been a widely discussed topic since 2002 when UNESCO coined the term in a global OER forum. OER was described (2002) as “technology enabled, open provision of educational resources for consultation, use and adaptation by a community of users for non-commercial purposes.” The research on OER has been focusing on potential usage in varying contexts, ranging from higher education (Yuan et al., 2008) and schools (Richter & Ehlers, 2011) to the corporate world (Manisha & Bandyopadhyay, 2009; Ha et al., 2011). Those cross-context studies are often connected to barriers or challenges that hinder OER adoption. These barriers are discussed on various levels, on the missing organizational support mechanisms (Chen, 2010; Yuan et al. 2008), lack of infrastructure and proper hardware (Chen, 2010; Hatakka, 2009), lack of quality of the resources as well as in the provided services (Clements & Pawlowski, 2011), and so forth. Existing research is yet to define in which contexts and even in which countries or regions certain barriers are likely to occur. One of the key issues in the literature that could explain contextual differences is culture and specifically, culture of OER sharing (Davis et al., 2010; Richter, 2011).

As argued by Kroeber and Kluckhohn (1952), there is no definite concept of culture. Scheel and Branch (1993) provided one possible description for it as a manifestation of patterns of thinking and behavior relating to social, historical, geographical, political, economical, technological, and ideological environment. Studying cultural factors or differences for TEL is not an entirely new focus. Richter and Pawlowski (2007) studied standardization of context metadata within e-learning environments. They defined *cultural metadata* and showed a number of factors concerning language, which is one of the key cultural factors. Those range from language, communication style, specific symbols, attitudes and perceptions of learners and educators, and culture-specific idioms, to more technological issues, such as types of date and time formats. As elaborated by a number of researchers, studying cultural differences can be problematic. Church and Katigbak (1988), e.g., argue that while “one needs culture-comparable constructs to make cross-cultural comparisons, their use may distort the meaning of constructs in some cultures or miss their culture-specific aspects.” Goldschmidt (1966) even goes a step further, claiming that it generally is inappropriate to compare cultures at all, as every “institution” needs to “be seen as a product of the culture within which it developed. It follows from this that a cross-cultural comparison of institutions is essentially a false enterprise, for we are comparing incomparables." As a consequence, most culture comparisons are limited to value systems, as there is a hope that there are general values, which at least play a certain (even if not exactly the same) role across most of the human societies. However, in such investigations, the position of the researcher rarely is neutral, as the perspective taken to choose particular values for comparison already is culturally biased. In a multinational study, Schwartz and Bilsky (1990) investigated 36 values in comparative culture research and found that just seven of those had the meaning of values across the investigated contexts. In order to overcome this challenge, we focus on educational contexts and define culture, according to Oetting (1993), as "customs, beliefs, social structure, and activities of any group of people who share a common identification and who would label themselves as members of that group" (herein, perceptions of educators and learners in the educational context).

Henderson (2007) described how the process of preparation of e-learning materials demands the analysis of cultural influence, especially when the separation of local, national, and international context of usage can be identified. Such separation of contextual modes is becoming even more prominent for OER as initiatives strive for aggregation of existing repositories or databases in one single access point (Ha et al. 2011; Sotiriou et al., 2013). Additionally, social interaction and collaboration mechanisms are crucial components of such environments, and they increase cultural influence. One way to address such cultural influences is to focus on cultural distance. The concept of cultural distance depends on the recipient's perceptions on how strong the difference between the home culture and host culture are; the greater the perceived difference, the more difficult it is to establish a relationship (Ward et al., 2001). As an example, such distance can be perceived when educators or learners try to adopt OERs or teaching practices that are exceptional or unfitting to their own context. Another case of clashing home and host culture could be when an educator is doubtful of joining a relevant conversation with a colleague from a distant location because it would not take place in her mother tongue. Investigating cultural distance provides information that crucially is required to decide when conflicts may occur in OER environments. In the context of OERs, cultural distance becomes a highly relevant issue when educators and learners shall use OERs from different contexts; being constantly exposed to potential learning materials and forms of collaboration that may not fit to their own preferences of working and learning or take place in their own native language.

Recent research in the educational domain shows the increasing interest toward social software. Social software can be described as a set of tools to enable interactive collaboration, managing content, and networking with others (Wever et al., 2007). While the application of social environments has been discussed as a support mechanism for pedagogy (Lai & Chen, 2011; Hall & Davison, 2007), the connection to OER is rather emerging. The focus of social and collaborative services in OER environments sets educators as key users of the environments. Such "collaborative content federations" (Ha et al. 2011; Sotiriou et al., 2013) often provide materials in various languages, while the environments are not equally translated to support international users. While language skills and preferences vary across educational level and countries, the preferences of educators and learners in terms of language or collaboration are not well known. As elaborated by Agarwal et al. (2007), knowledge-sharing activities of teachers and learners can be highly influenced by culture. Similarly, Noll et al. (2010) and Pallot et al. (2010) evidenced that culture and language distance are two of the strongest barriers in distributed collaboration, and this sets the focus for our study.

OER as well as social software research focuses on understanding particular barriers in order to overcome them. Solutions and interventions have been suggested as possible mechanisms to lower the barriers (Chen, 2010; Yuan et al., 2008; Hatakka, 2009), such as technology and policy-related strategies to be implemented (Chen, 2010) or short- to long-term drivers or enablers from cooperation to OER development (Yuan et al., 2008). Within this paper, we aim to determine mechanisms for lowering the barriers of cultural distance.

3 METHODOLOGY

Our study targeted school education, focusing on teachers and learners in primary and secondary schools across Europe. The aim was to find out 1) how far cultural distance is perceived as a barrier against the use of social OER environments, and 2) how to overcome such barriers.

In our study, we first investigated cultural distance barriers in general, by asking teachers and learners for their experiences regarding the use of (selected) social OER environments; we wanted to know which aspects in particular were understood as the major barriers against the use of existing OER environments. Second, we asked the participants to determine the improvement potential for the experimentally used social OER environments, in order to identify possible interventions that would be appropriate for overcoming the found barriers.

3.1 Operationalization of "Cultural Distance Barriers"

To address cultural distance barriers and to observe which aspects can predict its significance, a decision was made to operationalize related barriers into this one latent factor. The focus of the source literature has not fully covered all of the barriers to a culture of sharing and collaborating in OER environments. As discussed, studying cultural influence factors in a holistic setting is impossible because of the wide variety of cultural aspects and the lack of knowledge regarding their distinction (dependencies and interrelations). The approach for the operationalization and selection of related challenges was set based on the previously presented understanding of cultural distance by Ward et al. (2001). For our investigation, we focused on barriers that are related to aspects of sharing and collaboration in social OER environments, the language of collaboration, and the distance of the identified OERs they come across.

As the found literature has not focused on social OER environments, modification of approaches to analyze barriers was necessary. A particular barrier towards cultural distance that was found in the literature was related to knowledge sharing and collaboration (Noll et al., 2010; Pallot et al., 2010). This barrier was related to language component of cultural distance, as well as the perceived difference of the home and host context. As a common language is one of the greatest challenges for organizing distributed work (Noll et al., 2010; Pallot et al., 2010), we focused on this in our context. In our setting, teachers and learners are connected within an international community. The first item for our survey was therefore: "Language is the key". I only want to contribute to online communication/collaboration when my own native language is used (based on Noll et al. (2010) and Pallot et al. (2010)).

Richter & Ehlers (2011) and Hatakka (2009) discussed that teachers might experience an unmanageable distance when adapting resources from other cultural contexts particularly regarding language and culture-specific idioms. The second item chosen for the survey was: Challenging to apply digital educational resources which are culturally distant (values, symbols, beliefs, etc.) from my own (based on Hatakka (2009) and Richter and Pawlowski (2007)).

Distance can also result from a lack of trust against the authors of the OERs (Hatakka, 2009; Pallot et al., 2010). While cultural distance can be perceived without geographical or temporal distance (Noll et al., 2010), the notion of geography was included in the item to highlight the very likely geographic dispersion of users in the social OER environment. Thus, the third item was: Impact of cultural and geographical distance - Lack of trust towards authors of digital educational resources (based on Hatakka (2009) and Pallot et al. (2010)).

Another important issue that derived from OER research was that OERs often do not provide enough information on the context where they were created and designed for (Davis et al., 2010). This led to our fourth item: Digital educational resources do not give enough information on the context where it is / was created and used (based on Davis et al. (2010)). The focus was therefore set to study how the participants perceive OER that is created in a context that is distant from own, whether the distance has impact on the trust for the authors and providers of OER and if language plays a strong role for collaboration. The starting point of our analysis was, that these four culture barrier questionnaire items were indicators of a single latent factor.

3.2 Data Collection

The data collection was conducted within the scope of the Open Discovery Space project (ODS). The ODS (Sotiriou et al., 2013) is an EU-funded FP7 project that builds a social OER environment for the European school context around a federation of learning content repositories. In the context of the ODS project, workshops for teachers and learners were organized. In the context of these workshops, existing social OER environments were introduced: OERs within their topics of teaching (and interest) exemplarily were used, and the potentials for adopting these environments were discussed. In the end of the workshops, the participants were asked to complete a questionnaire that addressed the particular challenges the participants experienced in this experiment and their expectations toward the upcoming ODS portal. The role of each workshop was to introduce the concepts addressed in the questionnaire. This ensured that the respondents were aware of what was asked from them.

One of the main parts of the ODS-questionnaire focused on aspects that we addressed as being related to cultural distance. The depth of the survey, however, goes beyond the scope of this paper. The instrument was operationalized with a total of 23 items and 10 open questions. Other parts of the questionnaire addressed organizational and quality-related OER-barriers that were derived from OER-literature. The purpose was to see which barriers the respondents perceive as most critical. The second part of the survey included open questions asking for enablers and interventions to overcome such challenges. The inspection was solely limited to perceived cultural distance because of its significance in the analysis of both quantitative and qualitative data.

Approximately 2300 educators and learners participated in 92 workshops in 19 European countries. While schoolteachers were mainly expected to participate, ODS invited students, educators from higher education as well as policy makers to understand the restrictions and possibilities for influencing the European education system. The selection of schools was based on the longitudinal engagement plan of ODS for the schools of each country. Most of the workshops took place in a face-to-face setting and were organized by the local project partners. Four workshops were conducted online through video conferencing facilities. Each workshop focused on one or more particularly selected OER environment(s). The main criterion for the selection of the OER environments was related to supported social functionalities around the educational resources. The most frequently demonstrated environments within the workshops were:

- OpenScout – OER for business and management (http://learn.openscout.net)
- OSR – Open science resources (http://www.osrportal.eu)
- Discover the Cosmos – Astronomy resources (http://www.cosmosportal.eu)
- Photodentro – A Greek Digital Learning Object Repository (http://photodentro.edu.gr/lor/)

In the study, 1175 individuals from 19 European countries actually completed the questionnaire (nonresponse rate of 49%). The countries were: Austria, Belgium, Croatia, Cyprus, Estonia, Finland, Germany, Greece, Ireland, Italy, Latvia, Lithuania, the Netherlands, Portugal, Serbia, Spain, and the United Kingdom. The respondents were mainly educators in primary, secondary, and higher education. Additionally, a number of learners and policy makers completed our survey. For the analysis herein, we excluded policy makers and participants representing higher education and only considered the responses of teachers and learners from primary and secondary school education (N=855). The reason was to avoid mixing differing contexts of higher education and schools together. Additionally, the interventions could also be discussed more accurately when restricting the focus to a certain context. Some questionnaires were only partially completed. Because this was particularly the case in Romania, we finally excluded the country's participants from the evaluation. The mean age of the respondents was 37.4 years (SD = 11.1). Among the respondents, 69% were female, and 83% were teachers.

3.3 Data Analysis

The previously discussed four questionnaire items were used in constructing a summated scale to represent the cultural distance barrier for the study at hand. The reliability of the items was confirmed using principal axis factoring. Factor loadings over .50 were expected, as well as loadings relatively comparable in size. The reliability coefficient of the cultural distance scale was calculated using both factor score covariance and Cronbach's alpha. After the reliability inspections, we proceeded to construct a summated scale by calculating the average of the four cultural distance barrier items. The average of all variables was used instead of factor loadings, because the study was exploratory and we wanted to retain the original scale (from one to five). Any missing values for the culture barrier items were imputed to replace missing data. The amount of missing values for the selected four items was between 6.1% and 7.2%. Analysis of the missing value patterns revealed no significant differences between the gender and the role of the respondents.

To explore the country differences regarding experienced barriers based on cultural distance, a generalized linear model (GLM) predicting cultural distance barrier was constructed. The fixed factors of the model were, in addition to the country of the respondent, the gender and professional status (teacher or learner). The age of the respondent was used as a covariate. An intercept was included in the model, which was full factorial, e.g., interaction effects between the fixed factors were also tested.

The second part of our study was to look for potential interventions against the cultural distance barrier. This part of the survey applied open questions purposing to understand what could solve or lower the particular barriers reported by the respondents. The following open questions were applied to our survey for this purpose:

- "HOW COULD TECHNOLOGY SOLUTIONS AROUND RESOURCES SOLVE THESE PROBLEMS (E.G., ONES PRESENTED TO YOU/WHICH YOU TRIED IN THE WORKSHOP)?"
- "HOW WOULD YOU IMPROVE THE CURRENT SOLUTION?"
- "WHAT KIND OF HELP/TRAINING/TOOLS WOULD YOU NEED?"

Our intention was to find solutions to overcome the barrier of cultural distance. Key interventions against cultural distance barrier were found through clustering of the responses, which was accomplished with a focus on technical and organizational issues. The findings were understood as guiding steps for the ODS implementation.

4 STUDY RESULTS

The factor loadings for the four culture barrier questionnaire items that were derived in section 3.1 are displayed in Table 1. The Kaiser-Meyer-Olkin measure of sampling adequacy was .73, and Bartlett's test of sphericity was statistically significant ($p < .001$). The single factor solution displayed in Table 1 had an eigenvalue of 2.2, and explained 56% of the variance of the four cultural distance barriers. The reliability of the scale using factor score covariance was .74, and Cronbach's alpha was .72. The mean of the summated scale of culture barrier, calculated as the mean of the four items, was 2.65 (SD = 0.95), and both its theoretical and observed range was 1.00–5.00.

The results of the general linear model predicting the barrier of cultural distance are displayed in Table 2. The number of observations for GLM was smaller than for Principal Axis Factoring, because six respondents had failed to report their age and were therefore removed from this analysis. From the main effects, age and country were statistically significant. Gender, role (teacher/learner), and the interaction effects between the fixed factors were nonsignificant. The coefficient of the model intercept was 1.88, and the upper and lower bounds of 95% confidence interval were 1.50 and 2.29, $p < .001$. The coefficient of the age was.01 [.01, .02], $p < .001$. In other words, the older participants were more likely to report a higher barrier of cultural distance.

Table 1: Factor loadings for principal axis factoring of cultural distance barrier items.

Item	Loading
Challenging to apply digital educational resources which are culturally distant (values, symbols, beliefs etc.) from my own.	.71
Impact of cultural and geographical distance - Lack of trust towards authors of digital educational resources.	.69
Digital educational resources do not give enough information on the context where it is / was created and used.	.58
"Language is the key." I only want to contribute to online communication/collaboration when my own native language is used.	.54

Note. $N = 861$.

Table 2: General linear model predicting cultural distance barrier.

Source	df	*F*	sig.
Corrected Model	55	3.6	< .001
Intercept	1	227.3	< .001
Age	1	15.8	**< .001**
Gender	1	2.9	.088
Country	17	4.7	**< .001**
Role: teacher/learner	1	1.5	.227
Gender × country	17	1.0	.483
Gender × role	1	2.6	.111
Country × role	11	0.8	.581
Gender × country × role	6	0.4	.867

Note. $N = 855$. Model R squared = .20, adjusted = .14.

The GLM revealed how the cultural distance barrier depends on the nationality and age of the respondent. Results also indicated how the roles of teacher or learner do not explain the barrier of cultural distance. This implies that teachers are not more likely to perceive cultural distance barrier than learners and vice versa. The mean of the cultural distance barrier variable for learners was 2.52 (SD = 1.03), and for teachers 2.68 (SD = 0.93). For both males and females, the mean was 2.65, and standard deviations, respectively, were 0.93 and 0.96. The findings imply that the perceived cultural distance is not a barrier for majority but is likely to occur depending on the age and nationality of the teacher/learner.

The means of the cultural distance barrier variables between the countries are shown in Figure 1. Based on post-hoc analysis (least significant difference) we identified Croatia, Latvia, and

Estonia to be the countries with statistically significantly high means as compared to the countries with relatively low means: Austria, Belgium, Spain, Finland, Ireland, the Netherlands, Portugal, and Serbia. The implications of these results will be discussed in the last section of this paper.

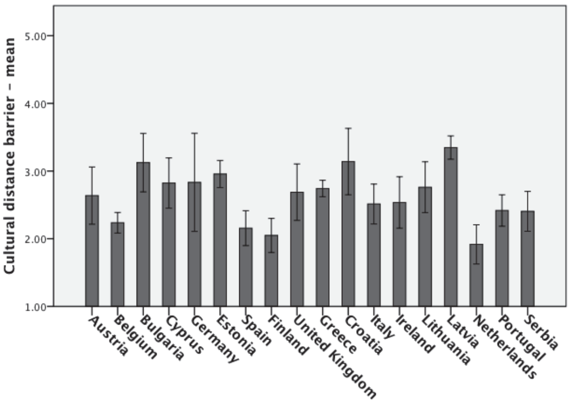

Figure 1: Country separation for cultural distance barrier. Smaller lines denote 95% confidence interval.

5 INTERVENTIONS

As previously explained, our research was not limited to investigating which parameters particularly affect cultural distance. In addition, we also studied interventions for the corresponding barriers. The answers we received on the open questions asking for potential mechanisms to overcome the barriers were related to both technological and organizational/contextual levels: Overcoming cultural distance barrier, firstly, regards the quality and suitability of the OER environment (technology) and, secondly, the community and OER initiatives themselves, as they act as change enablers toward new practices of sharing. In Table 3, both aspects for interventions are discussed.

In addition to the technical interventions, the respondents made recommendations to remove the barriers on the organizational level as well as the OER community-level (Table 4).

The results on interventions to potentially overcome or reduce barriers that are related to cultural distance indicate the key opinions of teachers and learners of our study. As shown in the technical dimension, the provision of functionalities as well as the variety of resources has to match the particular requirements and needs of the individual users. As presented in the previous section, not all users in the different European countries have the experience or are able to collaborate in a foreign language or to adopt OER that might be culturally distant. The key intervention seems still to be stimulating a change in OER knowledge-sharing practices by leading examples through the engagement and training activities of the OER initiatives that also provide the OER environments.

Table 3: Technical interventions.

	Key aspect	Explanation
Multilinguality	Resource availability in own native language	Many are unwilling or cannot handle foreign language
	Equal distribution of materials in different languages	Users need to have materials that are easy for them to apply
	Portal translated to own language	Shows that their language is important for the provider/developer
Functionalities	Methods for communication/ collaboration	Synchronous/asynchronous, Formal/informal
	Sharing and collaborating	With anyone, With selected people/group/community
User interface	Intuitive and localized for specific user groups	Providing customized views for s/learners from different countries/regions
Metadata provision	Rich and versatile metadata	E.g., indicating clearly for each resource, the context where it is created/used
Trusted communities	Quality mechanisms, indicating when resources are from reliable and active source	Aiming to increase trust toward user-/- generated content

6 DISCUSSION AND CONCLUSIONS

Within this paper we investigated the perception of cultural distance as a barrier against the use of social OER environments and ways to overcome those barriers. The perceptions of teachers and students from school education were in key role for defining whether they feel such cultural distance when using OERs and collaborating with international communities around those OERs. Our study focused on barriers against social software services that are provided for/within OER environments, creating social OER environments. As the understanding on how cultural distance barrier is perceived and how to overcome related challenges was rather limited, the findings of this study can provide a significant contribution to fill this gap. The results indicate how age and nationality affect the significance of cultural distance barrier. Younger respondents are more likely to experience a lower level of barrier when dealing with learning resources from and online collaboration with a distant culture. The results also evidence which of the 18 investigated countries' participants perceive cultural distance as a barrier. Interestingly, the professional role of the respondents did not significantly affect the perceptions towards cultural distance barrier.

The findings indicated that cultural distance is statistically significantly perceived as a barrier, particularly in the Baltic countries of Latvia and Estonia, and in Croatia. However, our study cannot explain why some countries had relatively low means in this context (e.g., Belgium, Spain, Finland, and the Netherlands). More research is needed to indicate the general validity of our results as well as to explain the reasons for the between-country deviations. While one argument could be that language skills and preferences differ between countries, such results might also be explained by awareness on OER in general. If the schools have a strong background in using textbooks, a rapid change to apply and modify OERs provided by an international community might not be realistic or trivial. Such a basic change of thinking and towards practical ways to approach preparation of lectures and teaching can be problematic. However, the findings do indicate how applying OERs that are prepared in/for a specific national/educational context might raise even more significant barrier within another context.

The influence of age regarding the perceived impact of cultural distance barrier is an important finding as it has not yet been reported in the context on OER. However, Onyechi and Abeysinghe (2009) reported similar results regarding the use of technology; they found that users under 35 years old are more likely to accept collaborative tools.

Regarding interventions against barriers that are related to cultural distance, we found both technical and nontechnical issues. The respondents elaborated on how social OER environments must fulfill their basic needs in terms of the quality of provided services and resources, and multilinguality. In order to generally reach a higher level of acceptance, OER initiatives should not just provide the technology

Table 4: Nontechnical interventions.

Key aspect	Explanation
Translating/localizing resources to fit the context	Setting a group within small communities and schools to translate the best materials for that purpose into their own language. Setting contests that include translation/localization/adaptation tasks, rewarded by the ODS network in cooperation with the local schools. Rewards could be free access to events such as summer school, training events, or conferences.
OER initiative stimulating the creation of knowledge-sharing culture in schools	Teacher's practices still vary for sharing their resources as well as using resources provided by others, even within their own schools. This process should happen from the bottom-up and then expand to the European level. To create this culture of sharing resources, experiences, and competencies with others, the OER initiatives should motivate teachers on local, national, and international levels to do so by showing some good examples of collaboration across countries.
	OER initiatives should aim to be open communities focusing on support and experience exchange. Teachers and learners should feel a sense of belonging and be given something that they feel comfortable using. Otherwise they might feel afraid that they'll be criticized about what they wrote or contributed.
	OER initiatives should provide opportunities for teachers to attend international training events, in order to help overcome cultural barriers in trusting resources from different cultures, as well as to feel that they are members of an international community.

for the OER usage but additionally foster the change toward openness in education. In this context, intense cooperation with the schools is required, e.g., approaching joint campaigns and collaborative efforts to contextualize/translate OERs for the contexts of the schools.

Our study and the related results have limitations: First of all, our results need to be limited to the context of school education, where the research took place. It is yet unclear to which extent those can be transferred to other educational scenarios. The participating schools were selected from existing networks of the partner organizations in the project. In many cases, only teachers from one specific area of the country participated. Thus, the sample might not be fully representative for all schools in the country. Additionally, we did not investigate the previous experience of the participants with OER. In retrospective, this might have been valuable information for both the analysis as well as the interpretation of the actually received results. We do acknowledge that the actual barriers differ between teachers in different contexts and educational institutions. However, this study focused on understanding to which extend teachers perceive cultural distance barrier when using OER environments, not to explain the types of barriers teachers face nor various cultural influencing factors that affect their behavior.

As the research was conducted as a part of the requirements analysis for the development of the social OER environment for the ODS project, the practical implications of our study are clear, especially for OER providers and developers: The results are relevant for any engagement activities with teachers and learners in similar OER scenarios. As OER provision through resource-/repository-federations becomes even more frequent, our results support the decisions on how to overcome some typical challenges. The results also give pragmatic suggestions to engage through the younger teachers as early adopters and community builders. Our findings can therefore help to significantly reduce efforts placed for the identification of needs and requirements of teachers and learners during the development of social OER environments.

Our contribution to research lies in the exploratory factor analysis conducted within this study. The identification of the factors representing barriers that are related to cultural distance provides a meaningful construct for future quantitative studies on OERs. Future studies on the topic could apply the proposed construct on variance models to verify and enrich existing theories on, e.g., technology acceptance. It would be important to address further studies to explain which barriers (e.g., lack of support within the organization, lack of awareness on OER) can predict barriers on the level of cultural distance.

ACKNOWLEDGEMENTS

This research has been co-funded by the European Commission through the CIP programme, Open Discovery Space, CIP-ICT-PSP-2011-5 297229 (cf. http://www.opendiscoveryspace.eu).

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Adaptive Content Sequencing without Domain Information

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Keywords: Sequencing, Performance Prediction, Intelligent Tutoring Systems, Matrix Factorization.

Abstract: In Intelligent Tutoring Systems, adaptive sequencers can take past student performances into account to select the next task which best fits the student's learning needs. In order to do so, the system has to assess student skills and match them to the required skills and difficulties of available tasks. In this scenario two problems arise: (i) Tagging tasks with required skills and difficulties necessitate experts and thus is time-consuming, costly, and, especially for fine-grained skill levels, also potentially subjective. (ii) Learning adaptive sequencing models requires online experiments with real students, that have to be diligently ethically monitored. In this paper we address these two problems. First, we show that Matrix Factorization, as performance prediction model, can be employed to uncover unknown skill requirements and difficulties of tasks. It thus enables sequencing without explicit domain knowledge, exploiting the Vygotski concept of Zone of Proximal Development. In simulation experiments, this approach compares favorably to common domain informed sequencing strategies, making tagging tasks obsolete. Second, we propose a simulation model for synthetic learning processes, discuss its plausibility and show how it can be used to facilitate preliminary testing of sequencers before real students are involved.

1 INTRODUCTION

Intelligent Tutoring Systems (ITS) are more and more becoming of crucial importance in education. Apart from the possibility to practice any time, adaptivity and individualization are the main reasons for their widespread availability as app, web service and software. The system generally is composed of an internal user model and a sequencer, that, according to the given information, sequences the contents with a policy. On that side many efforts have been put into Bayesian Knowledge Tracing (BKT), starting with not personalized and single skills user modeling. The limit of this problem formulation became clear soon, also because the contents evolved together with the technology. Multiple skills contents were developed, e.g. multiple step exercises and simulated exploration environment for learning. In order to maintain the single skill formulation systems fell back on scaffolding, i.e. a built in structure was inserted in order to clearly distinguish within the content between the different steps/skills required. As a consequence, the engineering and authoring effort to develop an ITS increased exponentially obliging a meticulous analysis of the contents in order to subdivide and design them in clearly separable skills.

Other efforts have been put into adaptive sequencing. The main approach used can be reconnected to robotics, which has an availability of accurate simulators and tireless test subjects. The same cannot be said for ITS where, generally, apart from adults, also children of any age are involved.

In this paper we propose a novel method of sequencing based on Matrix Factorization Performance Prediction and Vygotski concept of Zone of Proximal Development. The main contributions are:

1. A content sequencer based on a performance prediction systems that (1) can be set up and preliminary evaluated in a laboratory, (2) models multiple skills and individualization without engineering/authoring effort, (3) adapts to each combination of contents, levels and skills available.
2. Simulated environment with multiple skill contents and students' knowledge representation, where knowledge and performance are modeled in a continuous way.
3. Experiments on different scenarios with direct comparison with informed baseline.

The paper is structured as follows: in Section 2 one can find a brief state of the art description, in Section 3 the explanation of the sequencer problem, in Section 4 the simulated learning process, in Section 5 the performance based policy and predictor, in Section 6 the experimental results and least the conclusions.

2 RELATED WORK

Many Machine Learning techniques have been used to ameliorate ITS, especially in order to extend learning potential for students and reduce engineering efforts for designing the ITS. The most used technology for sequencing is Reinforcement Learning (RL), which computes the best sequence trying to maximize a previously defined reward function. Both model–free and model–based (Malpani et al., 2011; Beck et al., 2000) RL were tested for content sequencing. Unfortunately, the model–based RL necessitates of a special kind of data sets called exploratory corpus. Available data sets are log files of ITS which have a fixed sequencing policy that teachers designed to grant learning. They explore a small part of the state–action space and yield to biased or limited information. For instance, since a novice student will never see an exercise of expert level, it is impossible to retrieve the probability of a novice student solving some contents. Without these probabilities the RL model cannot be built (Chi et al., 2011). Model–free RL, instead, assumes a high availability of students on which one can perform an on-line training. The model does not require an exploratory corpus but needs to be built while the users are playing with the designed system. Given the high cost of an experiment with humans, most authors exploit simulated single skill students based on different technologies like Artificial Neural Networks or self developed student models (Sarma and Ravindran, 2007; Malpani et al., 2011). Particularly similar to our approach is (Malpani et al., 2011), where contents are sequenced with a particular model–free RL based on the actor critic algorithm (Konda and Tsitsiklis, 2000), which was selected because of its faster convergence in comparison with the classic Q–Learning algorithm (Sutton and Barto, 1998). Unfortunately, RL algorithms still need many episodes to converge and will always need preliminary trainings on simulated students.

Our developed content sequencer is based on student performance predictions. An example of state of the art method is Bayesian Knowledge Tracing (BKT) and its extensions. The algorithm is built on a given prior knowledge of the students and a data set of binary student performances. It is assumed that there is a hidden state representing the knowledge of a student and an observed state given by the recorded performances. The model learned is composed by slip, guess, learning and not learning probability, which are then used to compute the predicted performances (Corbett and Anderson, 1994). In the BKT extensions also difficulty, multiple skill levels and personalization are taken into account separately (Wang and Heffernan, 2012; Pardos and Heffernan, 2010; Pardos and Heffernan, 2011; D Baker et al., 2008). BKT researchers have discussed the problem of sequencing both in single and in multiple skill environment in (Koedinger et al., 2011). In a single skill environment the most not mastered skill is selected, whereas in the multiple skill this behavior would present a too difficult content sequence. Consequently, the contents with a small number of not mastered skills are selected. Moreover, (Koedinger et al., 2011) point out how in ITS multiple skill exercises are modeled as single skill ones in order to overcome BKT limitations. We would like to stress that the sequencing requires an internal skills representation and consequently, together with the performance prediction algorithm, is domain dependent.

Another domain dependent algorithm used for performance prediction is the Performance Factors Analysis (PFM). In the latter the probability of learning is computed using the previous number of failures and successes, i.e. the representation of score is binary like in BKT (Pavlik et al., 2009). Moreover, similarly to BKT, a table connecting contents and skills is required.

Matrix Factorization (MF) is the algorithm used in this paper for performance prediction. It has many applications like, for instance, dimensionality reduction, clustering and also classification (Cichocki et al., 2009). The most common use is for Recommender Systems (Koren et al., 2009) and recently this concept was extended to ITS (Thai-Nghe et al., 2011). We selected this algorithm for several reasons:

1. Domain independence. Ability to model each skill, i.e. no engineering/authoring effort in individuating the skills involved in the contents.
2. Having comparable results with BKT latest implementations (Thai-Nghe et al., 2012).
3. Possibility to build the system with a common data set, i.e. without an exploratory corpus.
4. Small computational time on a 3rd Gen Ci5/4GB laptop and Java implementation: 0.43 s for building the model with already 122000 lines, negligible time for performance prediction.

3 CONTENT SEQUENCING IN ITS

The designed system consists of two main blocks. The first one is the environment and is represented by

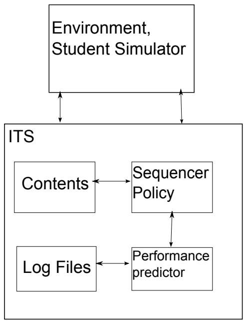

Figure 1: System structure in a block diagram.

the students playing with the ITS. In our case this role is simulated because an on-line evaluation is required, i.e. the sequence optimality can be measured only after a student worked with it. We excluded the possibility of collecting an exploratory corpus because making practice with very easy and very difficult exercises in random order could be frustrating for the students, who could be children. Moreover, having a simulated environment could help gaining the confidence necessary for experimenting on humans. Anyway, after a first validation with real students, only a common data set collection will be necessary to set up the system with new contents, giving also the possibility to calibrate the environment and later use it for new sequencing methods.

The second block consists of different modules, i.e. the available contents, the previous interactions of the students with the system (log files), the student Performance Predictor and the Sequencer Policy. We chose a specific Performance Predictor and policy, but nothing is against using other ones in the future. When a student plays with the system the next exercise is proposed to him by the sequencer according to a policy. The Performance Predictor needs the log files of students playing with the contents considered to predict their scores in the next contents. The policy is applied in an adaptive way thanks to the information on the predicted scores shared between Performance Predictor and Sequencer. In the following Sections we will describe the different blocks represented in Fig. 1.

4 SIMULATED LEARNING PROCESS

We designed a simulated student based on the following assumptions. (1) A content is either of the correct difficulty for a student, or too easy, or too difficult. (2) A student cannot learn from too easy contents and learns from difficult ones proportionally to his knowledge level. (3) It is impossible to learn from a content more than the required skills to solve it. (4) The total knowledge at the beginning is different than zero. (5) The general knowledge of connected skills helps solving and learning from a content. The last assumption is more plausible because we assume to sequence activities of the same domain. For instance, in order to solve a fraction addition, a student needs more related skills: multiplication, fraction expansion etc. It is unlikely for a student to do a fraction expansion without knowing how multiplication works. At the same time the knowledge of multiplication will help him solving the steps on fraction expansion.
A student simulator is a tuple (S, C, y, τ) where, given a set $S \subseteq [0,1]^K$ of students, s_i is a specific student described as a vector φ^t. The latter is of dimension K, where K is the number of skills involved. $C \subseteq [0,1]^K$ is a set of contents, where c_j is the j–th content, defined with a vector ψ_j of K elements representing the skills required. $\varphi_{i,k} = 0$ means student i has no knowledge skill k, whereas $\varphi_{i,k} = 1$ means having full knowledge. $\tau : \mathbb{S} \times \mathbb{C} \to \mathbb{S}$ is a function defining the follow-up state $\varphi^{t+1} = \varphi^t + \tau$ of a student $s_i \in \mathbb{S}$ after working on contents c_j^t. In particular $\mathbb{S}$ and $\mathbb{C}$ are the spaces of the students and contents respectively. Finally, a function y defines the performance $y(\varphi_i, \psi_j)$. y and τ can be formalized as follows:

$$\begin{aligned} y(\varphi_i, \psi_j) &:= \max\left(1 - \frac{||\alpha||}{||\varphi_i||}, 0\right) \\ \tau(\varphi_i, \psi_j)_k &:= y(\varphi_{ik}, \psi_{jk})\alpha_k \\ \tilde{y} &:= y\varepsilon \end{aligned} \tag{1}$$

where

$$\alpha_k^{i,j} = \max(\psi_{jk} - \varphi_{ik}, 0) \tag{2}$$

and ε is proportional to the beta distribution $\mathcal{B}(p,q)$. We selected p and q in order to have $\tilde{y} \sim \mathcal{B}\left(y, \sigma^2\right)$, where σ^2 is the variance, i.e. the amount of noise. We chose the beta distribution because it is defined between zero and one as the score. Consequently it will not change the codomain of the y function. The characteristic of the formulas are the following. (1) The performance of a student on a content decreases proportionally to his skill deficiencies w.r.t. the required skills. (2) The student will improve all the required skills of a content proportionally to his performance and his skill-specific deficiency up to the skill level a content requires. (3) As a consequence it is not possible to learn from a content more than the difference from the required and possessed skills. (4) A further property of this model is that contents requiring twice the skills level that a student has, i.e. $\left\|\psi_j\right\| \geq 2\left\|\varphi_i\right\|$, are beyond the reach of a student. For this reason

Table 1: Simulated learning process with two skills. A simulated student with $\varphi = \{0.3, 0.5\}$ scores y and learning τ after interacting with different contents c_j.

c_j	d_c	y	τ_k
$\{0.1, 0.1\}$	0.2	1	$\{0, 0\}$
$\{0.5, 0.6\}$	1.1	0.617	$\{0.12, 0.0617\}$
$\{0.5, 0.7\}$	1.2	0.515	$\{0.1, 0.1\}$
$\{0.9, 0.9\}$	1.8	0	$\{0, 0\}$

his performance will be zero ($y = 0$). With a simple experiment without noise, we can show the plausibility of the designed simulator. We inserted values in Eqs. 1 as follows. Let us consider a system with two skills and represent the student knowledge as $\varphi = \{0.3, 0.5\}$.

As it is possible to see in Tab. 1 with the increase of the content difficulty the learning increases and the score decreases until $\|\psi_i\| \geq 2 \left\|\varphi_j\right\|$. The maximal difficulty level is equal to the number of skills since a single skill value cannot be greater than one.

5 VYGOTSKI POLICY AND MATRIX FACTORIZATION

5.1 Sequencer

The designed sequencer is defined as follows. Let $C \subseteq \mathbb{C}$ and $S \subseteq \mathbb{S}$ be respectively a set of contents and students defined in Section 4, d_{c_j} be the difficulty of a content defined as $d_{c_j} = \sum_{k=0}^{K} \psi_{j,k}$, $\tilde{y} : \mathbb{S} \times \mathbb{C} \to [0, 1]$ be the performance or the score of a student working on the content, and T be the number of time steps assuming that the student is seeing one content every time step. The content sequencing problem consists in finding a policy:

$$\pi^* : (\mathbb{C} \times [0, 1]) \to \mathbb{C}. \tag{3}$$

that maximize the learning of a student within a given time T without any environment knowledge, i.e. without knowing the difficulties of the contents and the required skills to solve them. A common problem in designing a policy for ITS is retrieving the knowledge of the student from the given information, e.g. score, time needed, previous exercises, etc. The previous mentioned data types are just an indirect representation of the knowledge, which cannot be automatically measured, but needs to be modeled inside the system. Hence, integrating the curriculum and skills structure is the cause of the high costs in designing the sequencer.

In this paper we try to keep the contents in the Vygotskis Zone of Proximal Development (ZPD) (Vygotski, 1978), i.e. the area where the contents neither bore or overwhelm the learner. We mathematically formalized the concept with the following policy, that we called Vygotski Policy (VP):

$$c^{t*} = \operatorname{argmin}_c \left| y_{th} - \hat{y}^t(c) \right| \tag{4}$$

where y_{th} is the threshold score, i.e. the score that keeps the contents in the ZPD. The policy will select at each time step the content with the predicted score $\hat{y}^t$ at time t most similar to y_{th}. We will discuss further in the experiment session how to tune this hyper parameter and its meaning.

The peculiarity of the VP is the absence of the difficulty concept. Defining the difficulty for a content in a simulated environment as ours is easy, because we mathematically define the skills required. In the real case it is not trivial and quite subjective. Also the required skills are considered as given in the other state of the art methods like PFM and BKT, where a table represents the connection between contents and skills required. Without skills information not only BKT and PFM performance prediction cannot be used in our formalization, also sequencing methods (Koedinger et al., 2011) have no information to work with.

5.2 Matrix Factorization as Performance Predictor

Matrix Factorization (MF) is a state-of-the-art method for recommender systems. It predicts which is the future user ratings on a specific items based on his previous ratings and the previous ratings of other users. The concept has been extended to student performance prediction, where a student next performance, or score is predicted. The matrix $Y \in \mathbb{R}^{n_s \times n_c}$ can be seen as a table of n_c total contents and n_s students used to train the system, where for some contents and students performance measures are given. MF decomposes the matrix Y in two other ones $\Psi \in \mathbb{R}^{n_c \times P}$ and $\Phi \in \mathbb{R}^{n_s \times P}$, so that $Y \approx \hat{Y} = \Psi\Phi$. Ψ and Φ are matrices of latent features. Their elements are learned with gradient descend from the given performances. This allows computing the missing elements of Y and consequently predicting the student performances (Fig. 2). The optimization function is represented by:

$$\min_{\psi_j, \varphi_i} \sum_{j \in \mathbb{C}} (y_{ij} - \hat{y}_{ij})^2 + \lambda(\|\Psi\|^2 + \|\Phi\|^2) \tag{5}$$

where one wants to minimize the regularized squared error on the set of known scores. The prediction func-

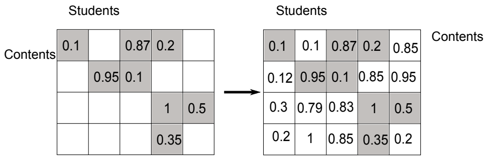

Figure 2: Table of scores given for each student on contents (left), completed table by the MF algorithm with predicted scores (right).

tion is represented by:

$$\hat{y}_{ij} = \mu + \mu_{cj} + \mu_{si} + \sum_{p=0}^{P} \varphi_{ip}^T \psi_{jp} \tag{6}$$

where μ, μ_c and μ_s are respectively the average performance of all contents of all students, the learned average performance of a content, and learned average performance of a student. The two last mentioned parameters are also learned with the gradient descend algorithm.

The MF problem does not deal with time, i.e. all the training performances are considered equally. In order to keep the model up to date, it is necessary to re-train the model at each time step. MF has a personalized prediction, i.e. a small number of exercises needs to be shown to each student in order to avoid the so called cold–start problem. Although some solutions to these problems have been proposed in (Thai-Nghe et al., 2011; Krohn-Grimberghe et al., 2011), we will show in the experiment session that these aspects do not affect the performance of the system, neither they reduce its applicability. From now on we will call the sequencer utilizing the VP policy and the MF performance predictor VPS, i.e. Vygotsky Policy based Sequencer.

6 EXPERIMENT SESSION

In this section we show how the single elements work in detail. We start with the student simulator, continue with the VP and end with some experiments with performance prediction in different scenarios and noise. A scenario is represented by a number of contents n_c, a number of difficulty levels n_d, a number of skills n_k, and a number of students for each group n_t[1]. All the first experiments will have no noise, i.e. $\tilde{y} = y$.

[1]The MF was previously trained with n_s students that were used to learn the characteristic of the contents. Consequently, the dimensions of the MF during the simulated learning process are: $\Psi \in \mathbb{R}^{n_c \times P}$ and $\Phi \in \mathbb{R}^{(n_s+n_t) \times P}$, so that $Y \approx \hat{Y} = \Psi\Phi$.

6.1 Experiments on the Simulated Learning Process

To prove the operating principle of the simulator we tested basic sequencing methods in a particular scenario. The one we chose is described in Fig. 3, with $n_d = 7$ and $n_c = 100$. For representation purposes we created the contents with increasing difficulty, so that IDs implicitly indicates the difficulty[2]. The scenario mimics an interesting situation for sequencing, i.e. when more apparently equivalent exercises are available. The two policies we used are (1) Random (RND), where contents are selected randomly, and (2) the in range policy (RANGE), where each second content is selected in difficulty order. This strategy is informed on the domain because it knows the difficulty of the contents. We initialized the students and contents skills with an uniform random distribution between 0 and 1. Again for representation purposes we show the average total knowledge of the students that is represented by average of the students skills sum at each time step. We chose to perform the tests on 10 skills, i.e. the maximal total knowledge possible is equal to 10. We considered the scenario mastered when the total knowledge of the student group is greater than or equal to the 95% of the maximal total knowledge.
Fig. 4 shows the total knowledge of two groups of $n_t = 200$ students, one group was trained with random policy the other one with the in range policy. RANGE is characterized by a low variance in the learning process. RND, instead, has a high variance because the knowledge level of the students at each time step is given by chance. It is shown that the order in which the student practices on the contents is important for the total final learning. Fig. 4 also shows how the practice on too many contents of the same difficulty level, after a while, saturates the knowledge acquisition. All these aspects demonstrate that the learning progress is plausibly simulated.

6.2 Sensitivity Analysis on the Vygotski Policy

In order to evaluate the VP we created two more sequencing methods that exploit information not available in reality. The best sequencing knows exactly which is the content maximizing the learning for a student, for this reason we called it Ground Truth (GT). Vygotski Policy Sequencer Ground Truth (VPSGT), instead, uses the Vygotski Policy and the

[2]A content with ID 2 is easier than a content with ID 100, see Fig. 3

true score y of a student to select the following content. GT and VPSGT can be considered the upper bound of the sequencer potential in a scenario. In order to select the correct value of y_{th} we plot the average knowledge level at time $t = 11$ for the policy with different y_{th}. From Fig. 5 one can see that the policy is working for $y_{th} \in [0.4, 0.7]$, this because of the relationship between Eqs. 1 of the student simulator. In a real environment the interpretation of these results is twofold. First we assume y_{th} will be approximately the score keeping the students in the ZDP. Second, from a RL perspective, this value would allow finding the trade–off between exploring new concepts and exploiting the already possessed knowledge. Moreover, as one can see in Fig. 6, the policy obtains good results if compared with GT for some y_{th}, but for others the policy is outside the ZPD and the students do not reach the total knowledge of the scenario. In some experiments we noticed that the width of the curve in Fig. 5 decreased so that the outer limits of the y_{th} interval create a sequence outside the ZPD. As consequence we selected the value $y_{th} = 0.5$ that was successful in most of the scenarios.

6.3 Vygotski Policy based Sequencer

The scenario we selected for the tests with the VPS has $n_c = 200$, $n_d = 6$, $n_k = 10$ and $n_t = 400$. In order to train the MF–model a training and test data set need to be created. We used $n_s = 300$ students who learned with all the contents in order of difficulty. We used 66% of the data to train the MF–model and the remaining 34% to evaluate the Root Mean Squared Error (RMSE) for selecting the regularization factor λ and the learning rate of the gradient descent algorithm. We performed a full Grid Search and selected the parameters shown in Tab. 2. The sequencing experiments are done on a separate group of n_t students. In order to avoid the cold start problem 5 contents are shown to them and their scores added to the training set of the MF. For $T = 40$ the best content c_j^{*t} is selected with the policy VP for the n_t students, using the predicted performance $\hat{y}_{ij}^t$. In order to avoid the deterioration of the model, after each time step the model is trained again once all students saw an exercise. A detailed description of the algorithm of the sequencer can be found in Alg. 1, where Y_0 is the initial data set. As one can see in Fig. 7 the VPS selects the first content similarly to RANGE. Then the prediction allows to skip unnecessary contents speeding up the learning. Once the total knowledge arrives around 95%, the selection policy cannot find contents that fit to the requirements. Consequently the students learn as slow as the RND group, as one can see from the saturating curve. In Fig. 8 GT selects the contents in difficulty order skipping the unnecesary ones. The average sequence of the VPS, instead, is also with approximately increasing difficulty but in an irregular way. This is due to the error in the prediction performance. In conclusion the proposed sequencer gains 63% over RANGE and 150% over RND.

Table 2: Parameters MF.

Parameters	Choice
Learning Rate	0.01
Latent Features	60
Regularization	0.02
Number of Iteration	10

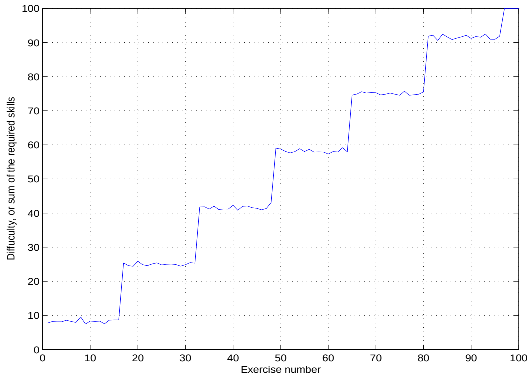

Figure 3: Scenario: Content Number and difficulty level.

Algorithm 1: Vygotski Policy based Sequencer.

Input: $\mathbb{C}$, Y_0 π, s_i, T

Train the MF using Y_0;
for t = *1 to T* **do**
  for *All* $c \in \mathbb{C}$ **do**
    Predict $\hat{y}(c_j, s_i)$ Eq. 6;
  end
  Find c^{t*} according to Eq. 5;
  Show c^{t*} to s_i with Eq. 1;
  Add $y(s_i, c^{t*})$ to Y_t;
  Retrain the MF; // Corrects over- or underestimation by the MF
end

The presented experiments show how the MF is able, without domain information, to model the different skills of students and contents and partially mimics the best sequence, which is the one selected by GT in Fig. 8.

6.4 Advanced Experiments

In this section we want to show the correct working of the sequencer changing the parameters of the scenario

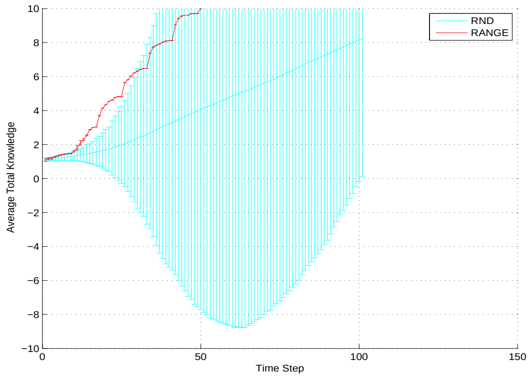

Figure 4: Comparison between RANGE and RND. Average skills sum, i.e. knowledge, over all the students with variance.

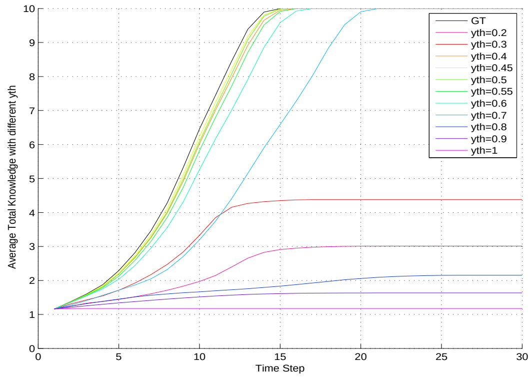

Figure 6: Effects of the different y_{th} on the final knowledge of the students. The learning curves of the student groups that learned with the different Vygotski policies.

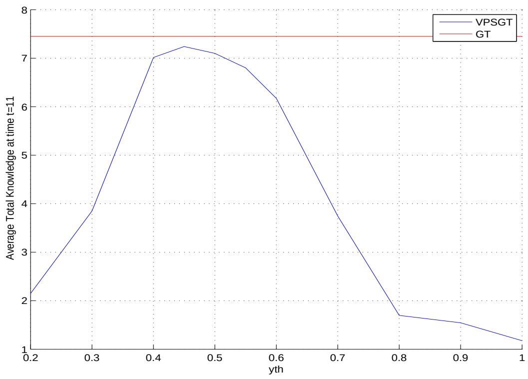

Figure 5: Policy selection, i.e. the performance of the Vygotski policy with different y_{th} at the same time step. Different groups of students learned with the Vygotski policy with y_{th} values going from 0.1 to 0.9. As shown in the figure the knowledge levels change according to the y_{th} selected.

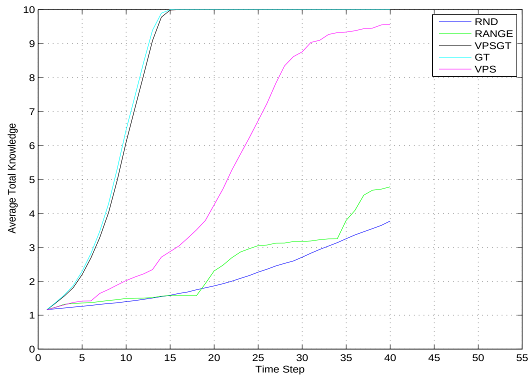

Figure 7: Average Total Knowledge. How the average learning curve of the students changes over time.

n_k and n_c and later adding noise. In order to do so we consider the percentage of gain of VPS with respect to RANGE considering a specific time step $t = 30$ with $n_k = 10$ and $n_d = 6$. As one can see in Fig. 10 the gain obtained by the sequencer depends on the available number of contents. Since in RANGE each second content is selected, with $n_c < 60$ there are not enough contents for all time steps. Our sequencer can adapt without problems to the situation. The optimal point for the in range policy is when $n_c = 60$ because there is exactly the necessary number of contents for the student to learn. When $n_c > 60$ the students see many unnecessary contents and consequently learn slower. Fig. 9 with $n_c = 60$, $t = 30$ and $n_d = 6$ shows the de-

Table 3: Baselines Description.

Policy	Description
Random (RND)	Contents are selected randomly
In Range (RANGE)	Each second content is selected in difficulty order.
Ground Truth (GT)	Selects the contents according to which is the one maximizing the learning.
Vygotski Policy based Sequencer Ground Truth (VPSGT)	Chooses the next content using the policy and the real score of a student.
Vygotski Policy based Sequencer (VPS)	Chooses the next content using the policy and the predicted score of a student.

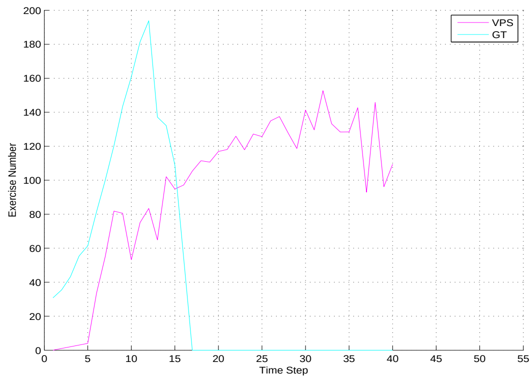

Figure 8: Average sequence selected by the GT and the VPS. The VPS approximate the optimal sequence that GT computes thanks to the real skills of the students.

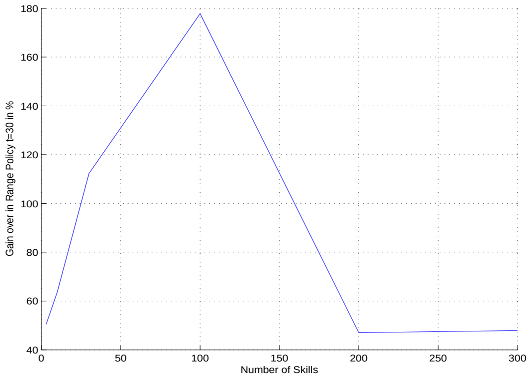

Figure 9: Gain over RANGE policy varying n_k. The gain is measured at a specific time step in percentage, considering the average knowledge level of the two groups of students, one practicing with the RANGE sequencer and one with the VPS.

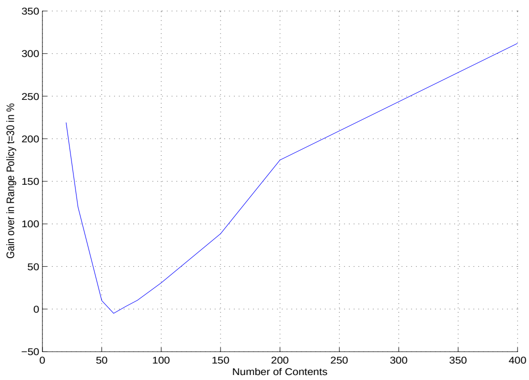

Figure 10: Gain over RANGE policy varying n_c. The gain is measured at a specific time step in percentage, considering the average knowledge level of the two groups of students, one practicing with the RANGE sequencer and one with the VPS.

pendencies between skills and gain. The experiments demonstrated a high adaptability of the sequencer to the different scenarios.

Last we experimented the results robustness adding noise, i.e. $\tilde{y} = y\varepsilon$. We experimented with $\sigma^2 \in [0, 0.5]$. As one can see in Fig. 11 with $\sigma^2 = 0.1$ the Vygotski sequencers are still able to produce a correct learning sequence but more time is required. The VPSGT is the one that suffered the most from the introduction of noise, probably related to the selection of y_{th}.

7 CONCLUSIONS

In this paper we presented VPS, a sequencer based on performance prediction and Vygotski concept of ZPD for multiple skills contents with continuous knowledge and performance representation. We showed

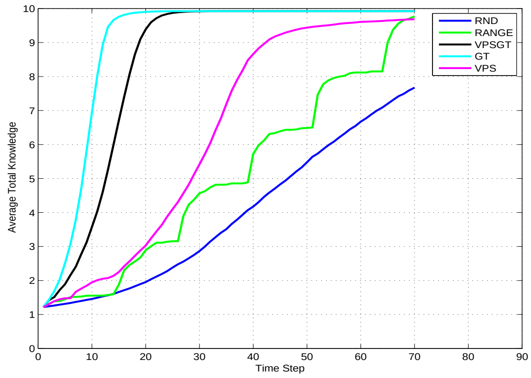

Figure 11: Effect of noise in the simulated learning process. Beta distribution noise with $\sigma^2 = 0.1$.

that MF is able dealing with the most actual problems of Intelligent Tutoring Systems, like time and personalization, retrieving automatically skills required and difficulty. We proposed VP, a performance based policy that does not require direct input of domain information, and a student simulator that partially overcomes the problem of massive testing with real students. The designed system achieved time gain over random and in range policy in almost each scenario and is robust to noise. This demonstrates how the sequencer could solve many engineering/authoring efforts. Nevertheless, an experiment with real students is required to better confirm the validity of the assumptions of the simulated learning process. A different evaluation is required for the performance prediction based sequencer. Since MF was already tested on real data, the main risk, in this case, is represented by the VP, which requires the tuning of the threshold score y_{th} on real students. Another minor risk, the over- or underestimation of the student's parameters by the performance predictor, was already addressed in (Koedinger et al., 2011) and is minimized here by retraining the model. In conclusion, to use VPS, no further analysis are required, since the MF will reconstruct the domain information, thanks to continuous score representation. The exploitation of performance predictors able to deal with continuous scores and knowledge representation are the future of adaptive ITS. With the results obtained in this paper we plan to extend such an approach also to other intervention strategies to further reduce the engineering efforts in ITS.

ACKNOWLEDGEMENT

This research has been co-funded by the Seventh Framework Programme of the European Commission, through project iTalk2Learn (#318051). www.iTalk2Learn.eu.

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The Effect of Music on the Level of Mental Concentration and its Temporal Change

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Keywords: Concentration, Attention, Music, Temporal Pattern.

Abstract: Concentration is one of the most important factor in determining the efficiency of learning. There has not been, however, much systematic research on controlling the level of concentration. We therefore examined the effect of an external factor, namely playing music, on the performance on a task that requires much attention. We compared three conditions: music that the subject likes, music that the subject is not familiar with, and silence. The result showed that listening to music that the subject likes do increase the performance level. Also, we discovered that there exist different temporal patterns in the change of performance. The result also indicated a relationship between the temporal pattern in concentration and the external factor.

1 INTRODUCTION

The efficiency of learning is highly dependent on the mental state that the person is in. When the person is highly concentrated, he can understand and memorize many complicated concepts in a short period of time, whereas when he is not concentrated, he cannot learn as effectively.

Although the change in the level of concentration is in part a spontaneous process, it is nevertheless affected by external factors as well. The effect is evident when one considers how productive he can be when the deadline is approaching. Surprisingly, there has not been much work in changing the environmental factors to create higher performance in learning.

Various books describing techniques to enhance concentration have been published, but most of them are solely based on personal experiences rather than objective experiments. For example, many students listen to music while they study at home. They seem to have learned from their experience that music increases their level of concentration. There has not been, however, much work on evaluating if music could be used to control the level of concentration.

In contrast to education, there is an extensive amount of research in the field of sports science, where all efforts are put to win a competition (Katch and Katch 1999). Physical and mental quantities of athletes are measured and analyzed to reach highest performance. The approach here is more objective and quantitative. If such approach was successfully applied to education the effect would be tremendous.

One of the ways to measure the effect of music on learning is to measure how concentrated the subject is. In this paper, we describe a system aimed at measuring the level of concentration based on the performance of the subject. We compare three conditions, namely playing music that the subject likes, playing music that the subject is not familiar with, and silence. The overall performance of the subject and the temporal change in the performance level will be compared and analyzed, to objectively evaluate if music have positive or negative effect on concentration.

The rest of the paper is organized as follows. In Section 2 we describe our model of concentration, and factors that would affect it. Section 3 is on implementation of our system. It is followed by Section 4 where we illustrates the design and the result of the experiment. Section 5 is on related work. Finally, Section 6 concludes the paper.

2 MODEL

For a person to learn something new, he/she has to be attentive to the content of learning. When a certain amount of contents are to be learned, sustaining attention for a certain amount of time is a requirement.

In this paper, we define concentration as a sustained high level of attention to the task. In order to measure it, we therefore employ a task that requires attention. Figure 1 illustrates the overall construction of our model. Arrows indicate causal relationships. Concentration is determined by internal parameters, which is affected by external factors. By changing the external factors, we assume it possible to change the level of concentration (or attention).

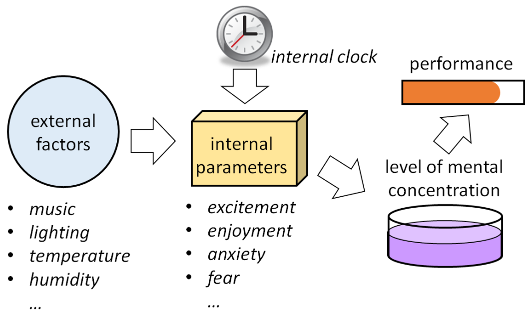

Figure 1: External factors and internal parameters.

In this paper, we mainly focus on how music and time affect the performance level on a task that requires concentration. We discuss the model in more detail in the following subsections.

2.1 Attention and Learning

In cognitive science, much work has been done to explain how attention affects different aspects of learning. The main position is even stated that there is no learning without attention (Schmidt 1995). A number of researchers have argued that different types of learning (e.g., explicit and implicit) depend on attention (Tomlin and Villa 1994).

Studies have inferred that attentional mechanisms is essential for all learning even for simple perceptual task (Ahissar and Hochstein 2002) and that more complex learning requires more attention (Schmidt 1995). One established principle of visual attention is that the harder a task is, the more attentional resources are used to perform the task and the smaller amount of attention is allocated to peripheral processing because of limited attention capacity (Huang and Watanabe 2012).

2.2 The Effect of Emotion on Attention

Some researchers have discussed that excitement may enhance attention and facilitate flexibility. On the other hand, it has been pointed out that positive mood may reduce the subject's performance (Schwarz and Clore 1983, Schwarz and Clore 1988, Rank and Frese 2008). When a subject experiences positive affective states, he assumes he is performing sufficiently well thus he withdraws effort. Also, in Cerin et al.'s model predicts that, in general, an affective profile characterized by mild to moderate intensity levels of threat-related affects (e.g. fear and apprehension) and affects conducive to or associated with approach behavior and task-focused attention (e.g. interest, excitement and enjoyment) will be perceived as facilitating performance (Cerin et al. 2000).

We however consider that the balance between excitement and calmness is important. If a person is overexcited, it often happens that he is distracted by any small stimuli and cannot concentrate on the task. On the other hand, if one's mind is too calm or relaxed, he would not feel like doing anything. The level most appropriate for a task lies somewhere in between excited and relaxed. We assume that listening to music that one likes has a modulating effect, with excitatory and inhibitory factors, helps achieve the best performance. Some music excites and other music calms. We assume that people know from experience which music is best for them to modulate music to sustain his/her level of attention. We test this hypothesis through experiments described in this paper.

2.3 Temporal Change in the Level of Attention

Time has various effects on cognitive performance (Grondin 2008). For example, it has been pointed out that attention is limited in time (Nobre and Coull 2010). Humans cannot sustain a high level of concentration for a long period of time. Learning is no exception. In practice, it is important to know how the level of attention changes, how it can be recovered, in order to make humans more productive.

It is also known that there are various rhythms in mental processes, from short ones to long ones (Buzsaki 2006). The level of concentration does not monotonically decreases either. It may have some rhythm, or it may rise as the end of the task approaches. It may follow different patterns other than rhythms, for example constant decrease in performance. By measuring the temporal change in performance, we try to uncover the temporal change of concentration. In this paper, we try to uncover such different patterns through experiments.

3 IMPLEMENTATION

We implemented a system aimed at controlling the level of concentration. In this section, we first describe a way to measure it, then describe the actual implementation.

3.1 Measurement of Mental Concentration

Our system measures the level of concentration using the amount of time required to perform a task that requires attention. It is based on a "conjunction search" task, where the subject is presented with signs that have combinations of features, such as shape, color, and orientation (Bergen and Julesz 1983). Figure 2 shows an example of the image presented to the subject when using our system.

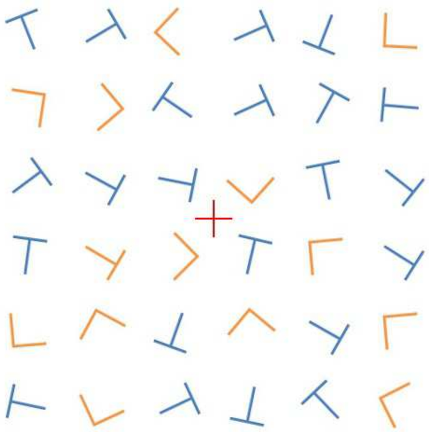

Figure 2: Conjunction search task.

The subject is presented with 100 signs, aligned into 10 rows and 10 columns, shown on a computer screen. Signs are in two types, namely *T* and *L*, and in two colors, blue and orange. The subject is asked to find a sign that is different from the rest in two aspects. For example, about half of the signs are blue *T*, and about the half are orange *L*, but there is one exception, either orange *T* or blue *L*. Once the subject finds it, he presses a key, and then the next trial starts. The exceptional sign is presented at different location each trial.

Usually, it is easy for a subject to find an exceptional sign when there is only one feature involved (Duncan and Humphreys 1989). It is an unconscious process, and the exceptional sign "pops out". In other words, the subject notices the exception without paying much mental effort.

On the other hand, one that is exceptional because of a combination of features, it requires much more time to find it. Usually, it requires conscious process for searching it. It means that consciousness is involved in the combinatorial search process. Considering the usual assumption that consciousness is closely related to attention, the task requires much attention, or concentration. By measuring the time required to find the exception, we can quantitatively evaluate the level of concentration. This type of test is widely used in psychology to measure the level of attention put by the subject.

In our system, the subject can click a sign by moving a pointer using the mouse. If the clicked sing is not the exceptional one, it is recorded as a mistake. By a preliminary experiment, we checked that time required for moving the pointer to the exceptional sign is negligible compared to time necessary for finding the sign.

3.2 Environmental Factors

As a control factor to affect the internal parameters, we chose to focus on music. Music affects emotion, making a person feel happy or sad. It is natural to think that it may affect internal parameters mentioned above. It has already been pointed out that it improves performance on spatial tasks (Schellenberg et al. 2007). Our experiments are to see if this is also true for tasks that involve concentration, and see if it can be quantitatively and systematically measured with an aid of a computer program.

In our experiments, we compared 3 conditions listed below.

1. Silence.
2. Music that the subject likes.
3. Music that the subject is unfamiliar with.

We chose to compare between music that are liked by the subject and that the subject is unfamiliar with. We assume that when the subject is listening to the music that he likes, performing the task becomes more enjoyable.

We asked the subjects to name a song that he/she likes, and used it in the experiment. For unfamiliar music, subjects were provided with music liked by other subjects, after checking that he/she is actually unfamiliar with it.

Using music that the subject likes is to determine the effect of enjoyment on concentration. The goal of our experiment is to determine whether the effect comes directly from the music itself, or is strongly influenced by the subject's liking to it.

3.3 Software

For implementing our system, we used PsychToolbox (Brainard 1997, Kleiner, Brainard and Pelli 2007), which is a set of functions run on Matlab, aimed at vision research. PsychToolbox contains various functions that could be used for creating psychological tests. For implementation, we used Octave, a Matlab compatible software.

4 EXPERIMENTS

We performed experiments on 12 subjects. All of them were undergraduate and graduate students, ranging from a freshman to 1st year in master's course. Using our system, we measured the number of trials each subject could perform during a set amount of time (15 minutes), under different conditions. Subjects were asked to perform trials as many times as possible. In other words, they were asked to find exceptional signs as fast as possible.

The types of music that were played were mostly pop music, with lyrics. There were up-tempo ones and slow-tempo ones, depending on the preference of each subject. When we could, we chose unfamiliar music from those that were liked by other subjects. This was to avoid the effect that comes from the types of music, for example the positive effect on concentration that may arise from listening to up-tempo music.

4.1 Comparison among Subjects

The numbers of trials that the subjects could perform under three conditions mentioned in the previous section is indicated in Table 1. The three conditions were silence, playing music that the subject likes, and playing music that the subject is unfamiliar with.

It shows scores for each condition, which are the numbers of trials that the subject succeeded within the time limit of 15 minutes. If the subject could complete each trial in a shorter time, he gets a higher score.

To avoid the effect from the subject getting used to the task and performing better in the latter part of the experiment, we arranged the conditions in different orders. The order of conditions the experiment was carried out for each subject is indicated by the second column of Table 1, using order IDs. The order is explained using Table 2.

The result shows that the average score were highest when the subject was listening to the music that he likes. The second highest was when he listened to the music that he is unfamiliar with, and the lowest was for the silence condition. It indicates that performance can be improved using music.

Table 3 shows the number of mistakes made by the subjects when carrying out the test. It shows that the number of mistakes was least when the subject was listening to the music he likes. Figure 3 illustrates the same information as a graph.

Table 1: Scores of subjects under different conditions.

Subject	Order	Silence	Like	Unfam.
A	I	98	89	113
B	I	86	84	84
C	II	119	119	96
D	II	54	61	69
E	III	71	72	62
F	III	106	132	109
G	IV	88	96	93
H	IV	109	105	105
I	V	116	131	138
J	V	115	110	112
K	VI	54	51	43
L	VI	40	56	53
Total		1056	1106	1077
Avg		88	92.17	89.75

Table 2: Order of testing.

Order	Silence	Like	Unfam.
I	1st	2nd	3rd
II	3rd	2nd	1st
III	2nd	3rd	1st
IV	2nd	1st	3rd
V	1st	3rd	2nd
IV	3rd	1st	2nd

Table 3: The number of mistakes made by subjects.

Subject	Silence	Like	Unfam.	Total
A	0	1	1	2
B	1	0	0	1
C	0	0	0	0
D	2	0	2	4
E	0	2	2	4
F	0	0	0	0
G	0	0	0	0
H	1	0	0	1
I	0	0	0	0
J	3	1	1	5
K	0	1	1	2
L	2	0	0	2
Total	9	5	7	21

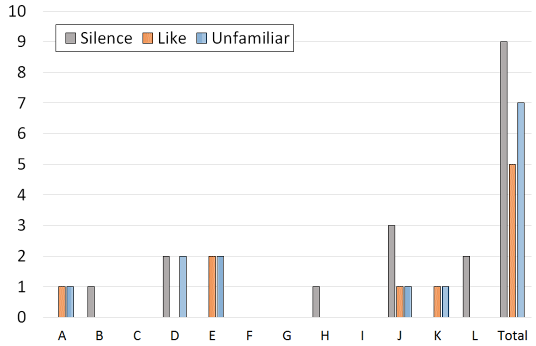

Figure 3: The number of mistakes made by subjects.

4.2 Temporal Change in Performance

In the experiment, each subject was asked to perform the task for 15 minutes, for each condition. After performing a task under one condition, the subject takes 5 minutes break.

Since the task is rather simple, so it is assumed that the subjects get tired with the task, or bored, which would lower the performance. Unless a high level of concentration is maintained, the performance level of the subject is unlikely to be constant.

Figure 4-9 shows one example of the change in the performance level as a subject did a sequence of trials. The x-axis indicates the trial ID and the y-axis indicates the time it took for the subject to complete that trial, i.e. to find the exceptional sign and click it.

The sequence of the times taken for finishing trials was considered as a function of sample points in time. We applied second order polynomial fitting to this function. The polynomials are also shown in the figures. They show the gradual changes of the performance levels.

Based on an observation, we grouped the result into three types. Type 1 is the case when the performance level does not change much. In this case, the polynomial is nearly constant. Type 2 is that the performance worsens as the time passes. In this case, the polynomial is a nearly linear increasing function. Type 3 is when the performance is best near the beginning and near the end, and worse in the middle. In this case, the polynomial is a convex function with its maximum in the middle part of the trial sequence. This is summarized in Table 4. In the table, a_2 is the coefficient of the quadratic term and a_1 is the coefficient for the linear term, for the second order polynomial fitting. Note that the performance is better when the y-value is lower.

The frequent appearance of Type 3 (high in the middle) was interesting, possibly indicating the rise in the performance level when the deadline is approaching.

In general, the overall performance level (the score the subject obtained) was highest for Type 1 and lowest for Type 3. Also, Type 1 was most frequent when the subject was listening to the music that he liked. On the other hand, Type 3 was most frequent when the subject was in the silence condition.

The result indicates that listening to preferred music condition raises the overall performance because it reduces occasions where the subject cannot find the exceptional sign and takes unusually longer time to finish the trial.

Table 4: Types in the temporal change of performance.

Type	**Polynomial fitting**	a_2	a_1
Type 1	Roughly constant	$a_2 \approx 0$	$a_1 \approx 0$
Type 2	Increasing	$a_2 \approx 0$	$a_1 > 0$
Type 3	High middle, low ends	$a_2 > 0$	

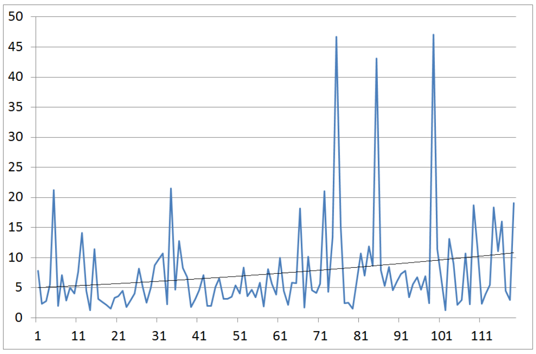

Figure 4: Temporal change under the silence condition (Subject C, Type 2).

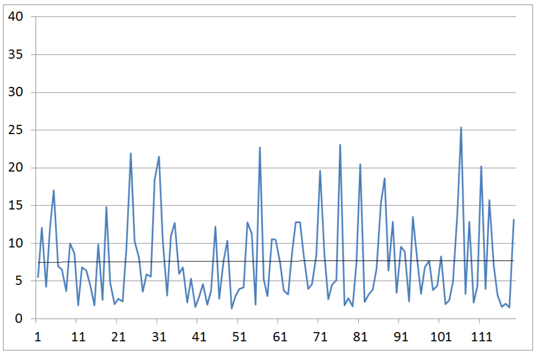

Figure 5: Temporal change under the liking music condition (Subject C, Type 1).

The regression curve may seem to be dependent on large values that intermittently occurs. However, since one of the aims of our experiment was to see the lack of attention, the fact that the subject took a long time to find the exceptional sign does carry information. We did not consider them as outliers.

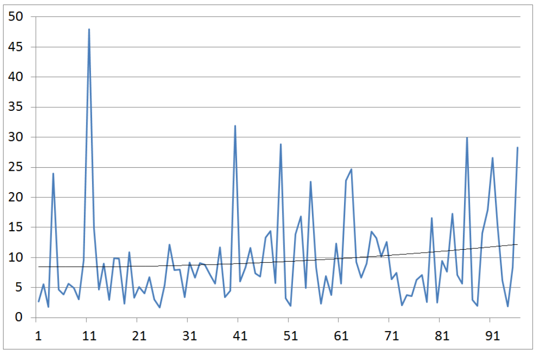

Figure 6: Temporal change under the unfamiliar music condition (Subject C, Type 2).

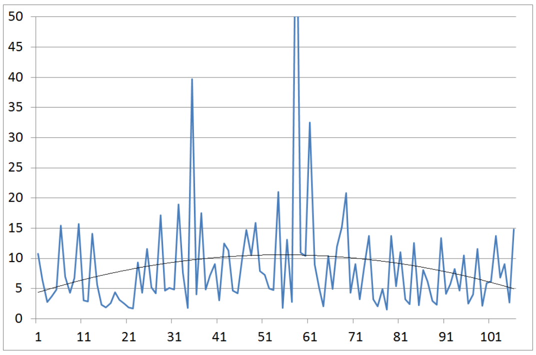

Figure 7: Temporal change under the silence condition (Subject F, Type 3).

4.3 Discussion

Our result that music affects the level of concentration have various application in the daily practicality of learning. When doing self-study, selecting appropriate music would help raise the performance. Even in a classroom, when it is not a lecture-style class but is a practice-style, it might help students by allowing them to listen to music while solving problems.

Teachers may even advice students to try out different types of music while studying, since our result

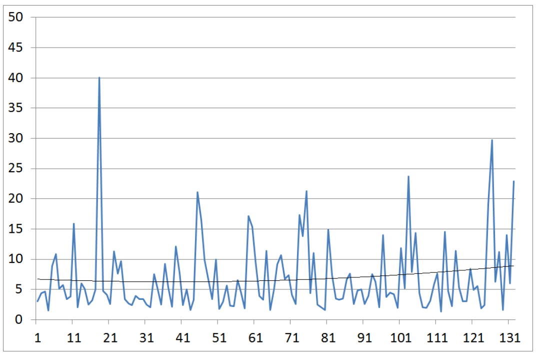

Figure 8: Temporal change under the liking music condition (Subject F, Type 1).

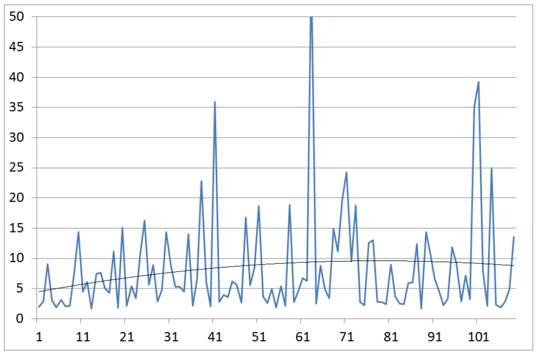

Figure 9: Temporal change under the unfamiliar music condition (Subject F, Type 3).

indicates that familiarity to music may affect the temporal change in the level of concentration.

Also, the method proposed in this paper to measure the level of concentration may be used for other purposes too, for example to know how long a subject can stay concentrated in learning.

5 RELATED WORK

In this section, we discuss related work from different aspects.

5.1 Factors That May Affect Mental Concentration

Onyper et al. tested a group of subject to solve puzzles or memorize items, while chewing gum (Onyper et al. 2011). They were compared with another group that did not chew gum during the test. The result indicated that chewing gum has positive effect on the subjects' performance. They state that chewing gum may wake you up and increase the level of concentration.

Nittono et al. found out that when the subject is presented with a cute ("kawaii", in recent terminology) picture preceding a task, his performance increased (Nittono et al. 2012). Although they hypothesized that a cute picture makes the subject focus on the details of it and increase his performance, it could also be resulting from the increased level of concentration due to excitement or enjoyment.

Our work is different from existing work in that it focused on music among many possible factors. It is also different in that it intended to capture the temporal change in the level of concentration in a short time span, i.e. in the order of seconds, which is much shorter than usually considered.

5.2 Cognitive Performance While Listening to Music

Rauscher et al. reported the superior spatial abilities for participants who listened to a recording of music composed by Mozart compared to those who sat in silence or listened to relaxation instructions (Rauscher, Shaw and Ky 1993). Because the performance was better on the spatial tasks after listening to Mozart, this result became known as the Mozart effect (Schellenberg 2005). Reviewing studies that examined effects of listening to music on cognitive performance can be divided to two general group: performance after listening to music and performance while listening to music or background music. Despite the difference, it is pointed out that music influences a wide range of behaviors including cognitive performance (Schellenberg 2012). In these studies, however, it was not checked whether the subjects actually liked Mozart. In comparison, we made a distinction between music liked by the subject and the one that the subject is not familiar with. Our result showed that while music itself raises concentration, the one that is liked works even better.

Shih et al. compared how music with, and without, lyrics affects human attention (Shih, Huang and Chiang 2012). Background music with, and without lyrics, was tested for effects on listener concentration in attention testing using a RCT (randomized controlled trial) study. The findings revealed that, if background music is played in the work environment, music without lyrics is preferable because songs with lyrics are likely to have significant negative effects on the concentration and attention of worker.

Patston and Tippett examined the overlap between music and language processing in the brain and whether these processes are functionally independent in expert musicians (Patston and Tippett 2011). A language comprehension task and a visuospatial search task were performed under three conditions: music-correct, music-incorrect, and silence for expert musicians and non-musicians. The performance of musicians was negatively affected by the presence of background music compared to silence when performing a language comprehension task. In contrast, the performance of non-musicians was not affected on either the language task by the presence of music played either correctly or incorrectly.

Cassidy and MacDonald studied the effects of HA (music with high arousal potential and negative affect), LA (music with low arousal potential and positive affect), and everyday noise, on the cognitive task performance of introverts and extraverts (Cassidy and MacDonald 2007). Performance was decreased across all cognitive tasks in the presence of background sound compared to silence. HA and LA music produced differential distraction effects, with performance of all tasks being poorer in the presence of HA compared to LA and silence, in the presence of noise than silence across all tasks, and in the presence of noise than LA in three of the four tasks.

Furnham and Strbac examined whether background noise would be as distracting as music (Furnham and Strbac 2002). In the presence of silence, background garage music and office noise, subjects with introvert and extravert personalities carried out a reading comprehension task, a prose recall task and a mental arithmetic task. Results found a significant interaction between personality and background sound on comprehension task only, although a trend for this effect was clearly present on the other two tasks. Participants performed best in silence, background music was second best for performance, and background noise was lowest results.

The existing work mainly focused on making comparison among music, silence and noise, whereas in our work music liked by the subject is compared with unfamiliar one. In this sense, it is more related to the emotion of the subject. Also, the existing work has not discussed much on how listening to music may affect the temporal change in the level of concentration. We designed and carried out experiments to check this effect.

5.3 Music for Enhancing Learning

Researchers from psychology as well as sociology have attempted to explain the importance of music for intellectual development by focusing on a variety of cognitive ability. Singer (Singer 2008) and Barker (Barker 2008) reported that music increased the chance students remembered what they had learned, by assisting the recall of information. Binkiewicz discussed the idea that songs are powerful pedagogical tools that enliven a classroom and enhance student learning in an enjoyable manner (Binkiewicz 2006).

When music is utilized learning, positive results occurred in achievement. Music showed positive impacts on achievement as Southgate and Roscigno assessed three patterns of music participation: in school, outside of school, and parental involvement in the form of concert attendance and possible effects on math and reading performance for both elementary and high school students (Southgate and Roscigno 2009). Their study captured the significant influence of music involvement for both math and reading achievement.

Paquette and Rieg described the benefits of incorporating musical experiences into daily instruction and argued that integrating experiences with music in the childhood classroom supports English language learners' literacy development (Paquette and Rieg 2008). Sims examined the effects of high versus low teacher affect and active versus passive student activities during music listening on preschool children's attention (Sims 1986). Data obtained through observation indicated that children were most attentive during music listening activities when the teacher exhibited high magnitude nonverbal affect, and when they were given a hand-movement activity in which to participate.

Our paper focused on the effect of music on the level of concentration, which is related to performance in general, rather than specific tasks in learning. By focusing on a simple task rather than complicated ones, we believe that we could quantify more fundamental parameter that affect the level of performance.

6 CONCLUSION

In order to increase the concentration level and raise the performance in learning, we implemented a system for measuring it, and examined the effect of an external factor, namely playing music that the subject likes. The result showed that playing music does have positive effects on the level of concentration, which would contribute to the performance level.

In future work, we would like to carry out experiments using more subjects, to make our result more statistically reliable. We would also like to look at the temporal patterns of concentration in more detail. We would like to see if there is actually rhythms for concentration, as mentioned by Buzsaki for different mental processes (Buzsaki 2006). We would like to explore this, for example using frequency analysis. We also plan to carry out more controlled testing, using a larger number of subjects, to validate our hypothesis.

We also plan to explore modulation of the excitement level using music, and see if the concentration can be improved. When the subject is too relaxed, we make him listen to excitatory music, and while the subject is overexcited, we make him listen to inhibitory music. We would like to see if the concentration level can effectively controlled that way. We expect the result to provide a fundamental basis for creating the environment most suited for learning.

ACKNOWLEDGEMENTS

This work was supported in part by JSPS KAKENHI Grant Numbers 21700121, 25280110, and 25540159.

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A Web-based System to Support Inquiry Learning
Towards Determining How Much Assistance Students Need

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Keywords: Hints, Feedback, Bayesian Network, the Assistance Dilemma, Inquiry Learning, Science Learning.

Abstract: How much assistance should be provided to students as they learn with educational technology? Providing help allows students to proceed when struggling, yet can depress their motivation to learn independently. Assistance withholding encourages students to learn for themselves, yet can also lead to frustration. The web-based inquiry-learning program, *Voyage to Galapagos (VTG),* helps students "follow" the steps of Darwin through a simulation of the Galapagos Island and his discovery of evolution. Students explore the islands, take pictures of animals, evaluate their characteristics and behavior, and use scientific methodology to discover evolution. A preliminary study with 48 middle school students examined three levels of assistance: (1) no support, (2) error flagging, text feedback on errors, and hints, and (3) pre-emptive hints with error flagging, error feedback, and hints. The results indicate that higher performing students gainfully use the program's support more frequently than lower performing students, those who arguably have a greater need for it. We conjecture that this could be a product of the current *VTG* program only supporting an early phase of the learning process and also that higher performers have better metacognition, particularly in knowing when (and when not) to ask for help. Lower performers may benefit at later phases of the program, which we will test in a future study.

1 INTRODUCTION

A key problem in the Learning Sciences is the *assistance dilemma:* How much assistance is the right amount to provide to students as they learn with educational technology? (Koedinger and Aleven, 2007). While past research with, for instance, inquiry-learning environments clearly points toward *some* guidance being necessary (Geier et al., 2008), it doesn't fully answer the assistance dilemma (which has also been investigated under the guise of "productive failure" (Kapur, 2009)). Essentially the issue is to find the right balance between, on the one hand, full support and, on the other hand, allowing students to make their own decisions and, at times, mistakes.

There are benefits and costs associated with both ends of this spectrum. *Assistance giving* allows students to experience success and move forward when they are struggling, yet can lead to shallow learning and the lack of motivation to learn on their own. On the other hand, *assistance withholding* encourages students to think and learn for themselves, yet can lead to frustration and wasted time when they are unsure of what to do. Advocates of direct instruction point to the many studies that show the advantages of assistance giving (Kirschner et al., 2006; Mayer, 2004), but this still does not address the subtlety of exactly when and how instruction should be made available, particularly in light of differences in domains and learners (Klahr, 2009).

Research in the area of scientific inquiry learning, where students tackle non-trivial scientific problems by investigating, experimenting, and exploring in relatively wide-open problem spaces, has provided various results about how different types of guidance support students. Researchers have built on inquiry learning theory (Edelson, 2001; Quintana et al., 2004) and have developed and experimented with simulations, cognitive tools, and microworlds to support inquiry learning in science. Systems of this kind that have demonstrated learning benefits include BGUILE (Sandoval and Reiser, 2004), the Co-Lab collaborative learning system (van Joolingen et al., 2005), a chemistry virtual laboratory (Borek et al, 2009; Tsovaltzi et al., 2010), WISE (Linn and Hsi, 2000; Slotta, 2004), and Metafora (Dragon et al., 2013). A large study by Geier et al. (2008) with over 1,800 middle-school students in the experimental condition versus more than 17,000 students in the control, showed that students who were given scaffolded tools for performing inquiry learning exercises (in earth, physical and life science) did significantly better on standardized exams than students who did not use the tools.

Thus, there is evidence that supporting and guiding students in inquiry learning is beneficial. Yet questions still remain: How much support is the right amount? How should assistance vary according to different levels of prior knowledge? To explore these questions we have developed (and continue to develop) a web-based inquiry learning system called *Voyage to Galapagos (VTG)* and will experiment with the software in a systematic manner intended to uncover how much help is necessary for students to learn about the theories of natural selection and evolution. At this stage of our research, we are testing various types of feedback across a spectrum of learners; we are not focused on varying / adapting the general type of feedback based on performance and prior knowledge. Eventually, we will adapt feedback to suit specific learners, but we first intend to answer the question of how much and what kind of feedback is appropriate for different learners with different levels of understanding. By fixing the feedback according to condition at this stage, we will learn, for instance, whether high assistance helps low prior knowledge learners and low assistance is better for high prior knowledge learners.

Voyage to Galapagos is software that guides students through a simulation of Darwin's journey through the Galapagos Islands, where he collected data and made observations that helped him develop his theories. The program provides students with the opportunity to do simulated science field work, including data collection and data analysis during investigation of the key biological principles of variation, function, and adaptation.

In typical inquiry learning fashion, the *VTG* program also provides a wide range of actions that a student can take. For instance, as they travel on the virtual paths of individual islands, students can take pictures of a variety of animals, some of which are relevant to understanding evolution, and some of which are not. This variety of action implies that there are also many possibilities to guide – or not guide – students as they learn and work through the program. Such variety also means that *VTG* is a rich instructional environment to experiment with the assistance dilemma and different amounts and types of guidance.

It is possible to provide assistance at different frequencies (e.g., never, when a student is struggling, or always) and different levels (e.g., flagging errors only, flagging errors and providing textual feedback, providing hints) in *VTG*. In the preliminary study presented in this paper, we evaluate assistance given according to these two dimensions and have conducted a classroom study with 48 middle school students. The study has provided us with initial insights and ideas about modifying and extending *VTG*, and we present and discuss our plans for a larger, more comprehensive study.

2 MISCONCEPTIONS ABOUT THE THEORIES OF NATURAL SELECTION AND EVOLUTION

Evolution is a fascinating academic topic to investigate because few students come to the subject without preconceptions and misconceptions. More often than not, students have misconceptions that must be overcome in order for them to learn and attain a correct understanding. Misconceptions that students have about evolution originate from multiple sources, all of which are related to prior knowledge, beliefs, and conceptions about the world (Alters and Nelson, 2002):

1. *From-experience Misconceptions* – Misconceptions that arise from everyday experience. For example, students may think "mutations" are always detrimental to the fitness and quality of an organism, since the word "mutation" in everyday use typically implies an unwanted outcome.
2. *Self-constructed Misconceptions* – Misconceptions from trying to incorporate new knowledge into an already incorrect concept. For example, students who think that evolution is somehow "progressive", always moving

toward more "positive" variations.

3. *Taught-and-learned Misconceptions* – Misconceptions that arise from informally learned and unscientific "facts." For example, watching movies with dinosaurs and humans can lead students to the mistaken idea that these species lived at the same time (and, of course, they did not).
4. *Vernacular Misconceptions* – Misconceptions that arise from the everyday use versus scientific use of words. For example, "theory" in everyday use means an unsubstantiated idea; the scientific use of "theory" means an idea with substantial supporting evidence.
5. *Religious and myth-based Misconceptions* – Ideas that come from religious or mythical teaching that, when transferred to science education, become factually inaccurate. For example, the belief that the Earth is too young for evolution, given the Bible's dating of the Earth at 10,000 years.

To start the project, in June 2011, we met with a focus group of seven experienced middle and high school teachers from diverse institutions to determine which misconceptions they observe most frequently in their students. The teachers ranked how frequently they encountered a set of 11 common evolution misconceptions in their classrooms. The set of misconceptions was derived from a literature review (e.g., AAAS, 2011; Alters, 2005; Anderson et al., 2002; Bishop and Anderson, 1990; Lane, 2011) and identification of the misconceptions that are relevant to *VTG*. The rankings ranged from, at the top, "Natural selection involves organisms 'trying' to adapt" to the bottom ranking of "Sudden environmental change is required for evolution to occur."

We conducted this focus group in order to better understand the learning of evolution and to develop educational technology that engages students' prior knowledge and misconceptions. Research has shown that if prior knowledge is not directly engaged, students may have trouble grasping new concepts (Bransford et al., 2000). Inquiry learning is one way to engage prior knowledge and overcome misconceptions. Prior work has shown that good scientific inquiry involves systematic steps such as formulating questions, developing hypotheses, designing experiments, analyzing data, drawing conclusions, and reflecting on acquired knowledge. Essentially, students who imitate (or are guided towards) the cognitive processes of scientific experts are most likely to benefit from inquiry (De Jong and van Joolingen, 1998; Klahr and Dunbar, 1988).

In addition, while undertaking these steps, students are likely to reveal and/or act upon their misconceptions, which, in turn, can be directly addressed by the feedback and guidance provided by an educational technology system. In a study with a science inquiry learning environment, Mulder, Lazander & de Jong (2010) concluded that there were two ways of assisting students: by providing domain support in order to increase the effectiveness of their natural inquiry behavior or by supporting their inquiry behavior at the level of domain knowledge. Quintana et al. (2004) called these content support and process support respectively. In this work, we focus on process support, helping students become better inquiry learners.

3 DESCRIPTION OF VTG

Our approach to overcoming misconceptions about evolution is to have students work with *VTG,* a web-based, inquiry program that mirrors Darwin's pathway to the development of the theories of natural selection and evolution. The program, which is largely implemented but still under development, encourages the student to follow the steps of good scientific inquiry, e.g., developing hypotheses, collecting and analyzing data, drawing conclusions. The program also reveals the basic principles of evolution theory to the students. Darwin's early ideas were initially inspired by his observations in the Galapagos Islands, where he noted the patterns of species distribution on the archipelagos. Darwin's observations in Galapagos (and other islands, during his long journey) spurred him to begin formulating his revolutionary ideas (Sulloway, 1982).

Students working with *VTG* have the opportunity to "follow" Darwin's steps and observe and analyze differences among island fauna. This occurs through a virtual exploration of six Galapagos Islands where students take photographs of different animals, watch videos of animal functions, conduct various analyses in a virtual laboratory, and come to conclusions based on assessments of the data.

The VTG program involves three main phases, or "levels":

- *Level 1: Variation* – photograph a sample of iguanas; measure the variation; analyze geographic distribution of variants
- *Level 2: Function* – watch videos on animal functions (e.g., eating, swimming, foraging for food); test animals for relative performance
- *Level 3: Adaptation* – see where animals with

specific biological functions live; hypothesize about selective pressures; draw conclusions

The student is presented with a video before working on each level, which explains key points about the inquiry process of that phase, relevant evolution theory, and prompts the student to begin work. Once the student starts working, they are given assistance according to their experimental condition. There are five possible conditions, varying from no to high assistance. (Only three of the conditions were studied in the preliminary study. These will be explained later in the paper.)

The study presented in this paper focuses only on Level 1, as this has been the focus of our initial feasibility and usability studies. Figure 1 shows a screen shot of *VTG* – Level 1 in which the student is located on the island of Fernandina in the Galapagos and has the viewfinder of her camera focused on an iguana. An overall view of the Galapagos Islands is shown in the upper right, and a close-up view of a portion of a selected island, in this case Fernandina, is shown in the lower right. The student can follow or skip around the virtual path on the selected island, by selecting individual steps that are in the close-up view of that island. When a step is selected, a picture of the view from that point on the island is shown (note: the pictures in the program were actually taken in the Galapagos).

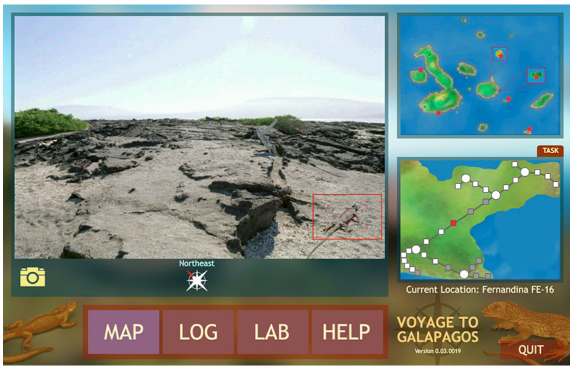

Figure 1: The *VTG* inquiry-learning program, Level 1. Here the student is about to take a picture of an iguana (centered in the red viewfinder box in the photograph).

As the student takes pictures of animals, they are stored in her Logbook, the central repository and organizing tool for the student's inquiry (see Figure 2). Students are instructed to collect iguanas that have as much variation between them as possible. They can take up to 12 photographs in an attempt to cover as wide a variety of iguana traits as possible.

The Lab is the place where students perform various analyses on the data they have collected. It

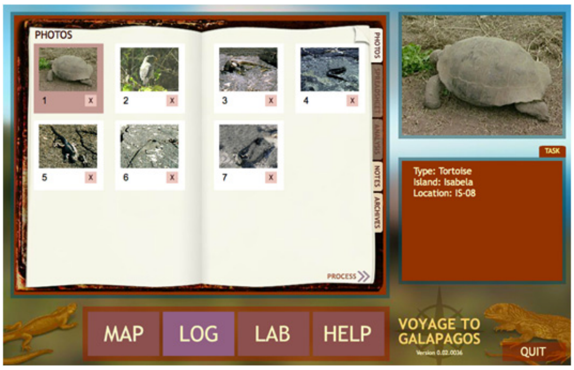

Figure 2: The Logbook of *VTG*. Here the student has taken 7 pictures – 5 iguanas 1 tortoise, and 1 finch. The student should be evaluating iguanas, so it is a mistake – but still permitted by the program – for the student to photograph the tortoise and finch.

provides a link between the three levels of the inquiry tasks that the student is asked to undertake. The Lab contains virtual software tools that the student can use in her analyses. The Schemat-o-meter is a tool that allows the student to examine, measure, and classify traits (e.g., length, tail, shape, color) of the collected animals (see Figure 3). The Trait Tester is a tool, in Level 2, that allows the student to test a hypothesis about the function of a trait variation. The Distribution Chart is a data analysis tool that allows the student in Level 3 to plot the various classified traits of the animals across the islands and habitats where they were collected.

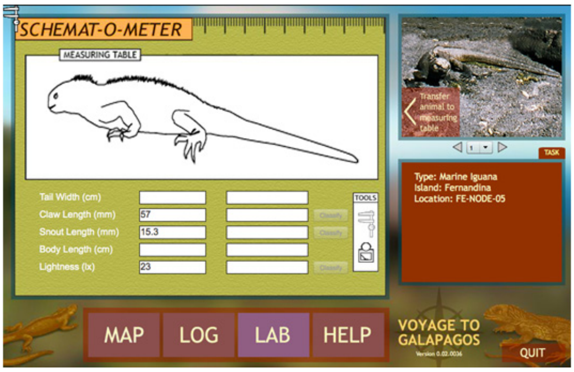

Figure 3: The Schemat-o-meter of *VTG* used to measure and classify traits of the collected animals.

There is considerable "student action" variability within *VTG*; that is, there are many degrees of freedom and opportunities for students to make mistakes. For instance, as shown in Figure 2, the student can take pictures of irrelevant species when they are supposed to focus on iguanas. The student might take pictures of a single animal, say iguanas,

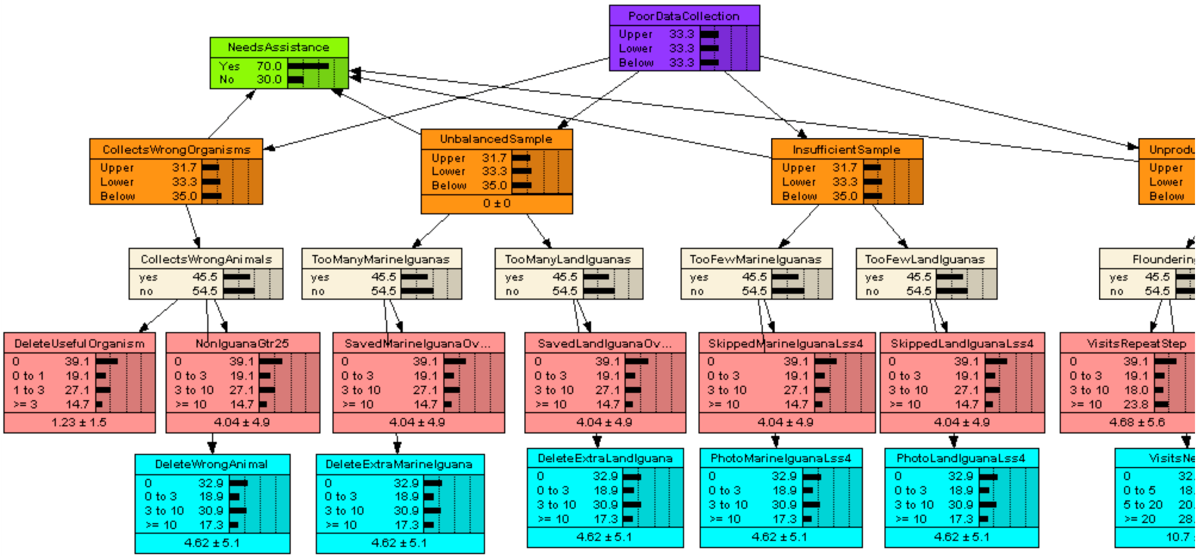

Figure 4: A fragment of the Bayesian Network for Level 1 of *VTG*.

but not take enough pictures to capture trait variation. The student can visit islands that have little useful data to collect or compare traits that will not be useful in learning about variation. This potential variability of student actions – and student errors – allows for a wide variety of assistance, and the ability to intervene with help after those actions are taken – or not. This provides the foundation for our experimental test bed.

A Bayesian Network is used to collect data about student actions, assign probabilities of students having made certain errors, and make decisions about when to turn assistance on so that students receive error feedback and hints, provided students are in conditions to receive such assistance.

The Bayesian Network has four layers (see Figure 4), which are (from the bottom upwards)

1. Supportable events
2. Error diagnosis
3. Error evaluation

Knowledge, Skills and Abilities (KSA) evaluation

The supportable events layer is the first layer of the Bayes Net, and it is where the system captures student actions—both positive and negative (see the bottom two rows of Figure 4)—capturing a combination of things such as the student's location, data collection and state of their logbook. As a student performs an action that has been designated as a supportable event (i.e. one that contributes to our understanding of whether or not a student needs assistance and the nature of their need) the action is recorded. For example, if a student has just stepped away from a place on a path on an island where there is a land iguana (location) without photographing it (action) and she has fewer than four iguana photos saved in her logbook (state of logbook), this is recorded and evaluated by the Bayes Net.

The error diagnosis layer is the second layer (see the middle row of nodes in Figure 4) of the Bayes Net, and its purpose is to determine the type and magnitude of the support a student needs. Each type of assistance a student might need is represented by a node in this layer. The starting state of a node is zero and, as data are received from the supportable events, the probability value of the node will increase or decrease.

The error evaluation layer is the third layer (see the second row of nodes from the top in Figure 4) of the Bayes Net, and its nodes monitor the kinds of errors that the student is making so that, when assistance is turned on, the error feedback can be targeted at the students' need.

The Knowledge, Skills and Abilities (KSA) evaluation layer (see the top row of nodes in Figure 4) is the fourth and highest level of the Bayes Net, which monitors the student's progress toward the instructional targets of the *VTG* module in the sub areas of science practices and science knowledge. The probability values in the nodes of this level are used to report to the student and the teacher progress in their development of knowledge and skills as a result of working through the *VTG* tasks. Nodes at this level are linked to other relevant nodes at the same level in other tasks so that information about a students' science inquiry skills and knowledge is passed from one task to another, by establishing a beginning value for the node in the new task. This allows the assistance system to weight the level of assistance according to past performance on preceding tasks.

In addition to the four layers of the Bayes Net described above, there is an assistance node in the network, which can be seen as the node in the upper left of Figure 4. As can be seen from Figure 4, the assistance node has edges (the directional lines with arrows in the diagram) that connect to it from nodes in the error evaluation layer. The assistance node is essentially a switch that turns the assistance to the student on or off, depending on its level of activation. The node monitors the probability that the student needs assistance based upon their actions to date. When the probability exceeds a threshold value, the assistance will turn on. Whether a student receives the feedback is configurable according to what experimental condition they are in. By allowing the assistance to be configured in this way, we are able to create the conditions of assistance that are the focus of our experimental design, which is discussed next. As a student receives assistance and s/he corrects the errors made, the probability values of the nodes will drop. Assistance turns off when the probability that the student still needs support falls below the threshold value.

4 STUDY TO EXPLORE THE ASSISTANCE DILEMMA IN VTG

We have two research questions to answer with our quasi-experimental design:

1. How much assistance do students who learn with *VTG* require to achieve the highest learning gains and maximize their inquiry-learning skills?
2. Which mode of assistance is optimal for students with high, medium, and low levels of prior science knowledge and practices?

Our goal is to find the right balance between, on the one hand, full support (i.e., keeping students focused on the learning goals of the program and avoiding mistakes) and, on the other hand, minimum support (i.e., allowing students to make their own decisions and, at times, mistakes).

4.1 General Experimental Design

Our approach and implemented conditions within *VTG* conceives of this as a spectrum of assistance, driven by two orthogonal variables, *Frequency of Intervention* and *Level of Support*. *Frequency of Intervention* is characterized as being in one of three possible states:

- "Never" is when the system does not intervene;
- "When Struggling" is when the system detects that the student is making repeated errors or off-task actions (in this condition students might make several errors before the system decides that they are struggling); and
- "Always" is when the system intervenes at every error or off-task action.

Level of Support is characterized as having three levels of increasing support:

- "Error Flagging" is when an error is flagged by a red outline and exclamation mark only;
- "Error Flagging + Error Feedback" is flagging of the error plus an explanation of the error made; and
- "Error Flagging + Error Feedback + Hints" is flagging of the error, plus explanation, with a series of three levels of available hints.

Table 1 shows the research design that results from crossing these two variables. This 3 x 3 matrix provides a maximum of 9 assistance conditions, but we have combined some of the cells and will not be testing two others, resulting in five conditions (highlighted in yellow in the table).

First, a *Frequency of Intervention* of "Never" essentially means that no assistance will ever be provided, so the *Level of Support* variable is not applicable in that case. Thus, we combine all three cells of the first column of Table 1 to create a single condition, Condition 1 - *No Support*.

Second, we wanted to have a relatively wide mid-range of assistance, achieved by having variations of "When Struggling": Condition 2 – *Flagging, When Struggling*; Condition 3 – *Flagging & Feedback, When Struggling*; and Condition 4 – *Flagging & Feedback & Hints, When Struggling*. In all three of the "when struggling" conditions the provision of assistance is predicated on the current value of nodes in the Bayesian Network, as discussed in the previous section. In particular, when the probability of the student needing assistance exceeds a given threshold for a particular task, the student is assumed to be "struggling" and support is provided, as appropriate to that condition. For instance, in Level 1 students are required to photograph a balanced sample of land and marine iguanas. If a student photographs only land iguanas and no marine iguanas, each time they add a land iguana to their sample, it will increment the probability of "Unbalanced Sample" in the Bayes Net. That node, with others, is connected to an assistance node that switches assistance on at a certain threshold value. When assistance is turned on, the next time a student photographs a land iguana or passes a marine iguana without photographing it, the *VTG* software will provide assistance.

Third, we wanted to include the most extreme level of assistance (i.e., always providing all three levels of support, and also providing pre-emptive assistance): Condition 5 – *Full Support.*

Finally, we wanted to limit the total number of conditions in the experiment, so we would have statistical power in our analysis. Thus, we exclude the somewhat less extreme forms of full support (those in the upper right of Table 1).

Table 1: The Experimental Design, crossing two variables of assistance.

Level of Support	Frequency of Intervention: Never	When Struggling	Always
Error Flagging	Condition 1 *No Support*	Condition 2 *Flagging, When Struggling*	Skipped Condition *(Would be Flagging always)*
Error Flagging + Error Feedback		Condition 3 *Flagging & Feedback, When Struggling*	Skipped Condition *(Would be Flagging & Feedback always)*
Error Flagging + Error Feedback + Hints		Condition 4 *Flagging & Feedback & Hints, When Struggling*	Condition 5 Full Support

Ultimately, we will randomly assign approximately 500 students to these five conditions and run an experiment in which we will compare conditions and determine which level of assistance leads to the best learning outcomes, both overall and per different levels of prior knowledge.

With respect to our first research question (i.e., "How much assistance do students who learn with *VTG* require to achieve the highest learning gains and maximize their inquiry-learning skills?"), our hypothesis is that one of the middle conditions – *Flagging, When Struggling; Flagging & Feedback, When Struggling* or *Flagging & Feedback & Hints, When Struggling* – will lead to the best domain and inquiry learning outcomes for the overall student population. These conditions all trade off between assistance giving (such as what is provided by Condition 5) and assistance withholding (such as what is provided by Condition 1). With respect to our second research question (i.e., "Which mode of assistance is optimal for students with high, medium, and low levels of prior science knowledge and practices?"), we hypothesize that Condition 1 (no assistance) will be most beneficial to higher prior knowledge learners and Condition 5 (high assistance) will be most beneficial to lower prior knowledge learners. Our theory is that higher prior knowledge students are more likely to benefit by struggling a bit and exploring without guidance, while lower prior knowledge students, those who are more likely to experience cognitive load (Paas, Renkl, & Sweller, 2003) if left on their own, are more likely to benefit by being strongly supported.

4.2 Experimental Design for the Preliminary Study

4.2.1 Design and Participants

For the purposes of the preliminary study reported in this paper, we reduced the five conditions to three: Condition 1 - *No Support*; Condition 4 – *Flagging & Feedback & Hints, When Struggling*; Condition 5 – *Full Support.* We reduced the conditions as part of our iterative design and development plan. At this stage, we are hopeful of getting a general indication that we are moving in the right direction before conducting the much larger study with all five conditions. In addition, since we had a limited number of participating middle school students in the preliminary study (48), we wanted to have enough students per condition to analyze and report reasonable results. Two classes of a 7th Grade life science course from a suburban San Diego school participated in the study. Of the 48 participating students, 24 were male and 24 were female, with ages ranging from 11 to 13. All students were assigned to one of three conditions as follows:, 13 students were assigned to Condition 1, 25 students were assigned to Condition 4, and 10 students were assigned to Condition 5.

4.2.2 Materials

For this preliminary study, only "Level 1: Variation" was used in order to complete the study in a single 50-minute period. In addition, the teacher provided a rating of each student's science content understanding (Low, Medium, High) and inquiry skills (Low, Medium, High). We had the teacher provide this information, as opposed to having the students take a pretest, because we had limited class time available to us and wanted to focus on student use of the instructional software. The classes had been previously exposed to the evolution curriculum. Ultimately, *VTG* will be embedded within this curriculum.

4.2.3 Procedure

After a brief introduction to *VTG* by the teacher, Students were given the rest of the 50-minute class period to work with *VTG* (Level 1). This time included viewing an introductory video that provides a brief introduction to the theory of evolution and some general instructions on use of the program. While all learners were presented with the same task – to learn about evolution from the VTG program – they were free to take different pathways through the software in tackling the task and not all students completed the task. This is the very essence of inquiry learning: To explore and to “inquire” in different, perhaps idiosyncratic and incomplete ways.

4.3 Results

A total of 19 of the 48 students were able to complete Level 1 during their single class period of work. An additional student completed Level 1 after school, resulting in a total of 20 students who completed the work. We evaluated how productively the 48 students worked with *VTG* by collecting and calculating the following data:

- *Productive Events*: Actions taken by the student within the VTG software that help to achieve the goals of a particular level (e.g., For Level 1: Photograph a balanced sample of iguanas: 4 marine, 4 iguana; Correctly measure and classify variation).
- *Unproductive Events:* Actions taken by the student within the VTG software that do not help to achieve the goals of a particular level (e.g., For Level 1: Photograph animals other than iguanas; Photograph more iguanas than needed, etc.). These events are effectively errors; steps the student takes that are unlikely to advance his or her understanding of evolution.
- *Ratio of Productive / Unproductive Events*: This is a rough indicator of how productively students work towards solving the Level 1 task, with larger values being better.

To categorize students as high, medium, or low achievers, we took the teacher assessed scores (i.e., content understanding, inquiry skills, with a range of High=3; Medium=2; Low=1 for each), added the two scores together, giving a score between 2 and 6. Students with a score of 6 were labeled “High Achievers”, students with a score of 3, 4, or 5 were labeled as “Medium Achievers” and students with a score of 2 were labeled as “Low Achievers.” The high, medium, and low achievers in each of the conditions (1, 4, and 5) are shown in Table 2, along with an average number of productive events, average number of unproductive events, and ratio of productive to unproductive events for each category.

Table 2: The results of student use of *VTG – Level 1.*

Category	#	Avg. Prod. Events	Avg. UnprodEvents	Ratio Prod / Unprod. Events
High Achievers Condition 1 - No Support	6	144.5	25.7	5.6
High Achievers Condition 4 - Support	4	125.3	27.3	4.6
High Achievers Condition 5 - Full Support	5	107.0	15.8	6.8
Medium Achievers in Condition 1 - No Support	4	142.3	19.8	7.2
Medium Achievers in Condition 4 - Support	9	111.3	33.9	3.3
Medium Achievers in Condition 5 - Full Support	2	98.5	6.5	15.2
Low Achievers in Condition 1 - No Support	3	99.3	25.3	3.9
Low Achievers in Condition 4 - Support	12	117.3	33.1	3.5
Low Achievers in Condition 5 - Full Support	3	72.3	24.7	2.9

5 DISCUSSION

We emphasize once again that the study and analyses reported here are preliminary; they will be soon be followed by a more extensive experiment with a larger population of students, where we will do more extensive analyses. Thus, this should be considered a preliminary study with only suggestive results.

That said, the ratio of productive to unproductive events shows an interesting pattern, at least with respect to high achievers versus low achievers. Notice that the high achievers appeared to become *more* productive when they received more support (productive to unproductive ratio from 5.6 to 4.6 to 6.8), whereas low achievers appeared to become *less* productive when they received more support (productive to unproductive ratio from 3.9 to 3.5 to 2.9). Medium achievers generally followed the high achievers pattern of improving with support (yet with only 2 students in the medium, full support condition these results are more suspect).

Although the numbers are small and certainly not generalizable, as well as the results pointing more or less in the opposite direction of our general hypothesis (i.e., that higher achievers will do better with less support, lower achievers will do better with more support), we believe there is an underlying rationale to what we've uncovered thus far. *VTG* and this activity was novel to all students, low and high achievers alike, thus all students may have needed support to tackle the task, especially during this early phase of the work (i.e., Level 1). However, the high achievers, as better students are wont to do, seemed to more productively use the provided help (see e.g. Aleven et al., 2006). We believe this could very well change over time, after the higher achievers better understand the process and lower achievers realize the benefits that could come from using the *VTG* support. In any case, the data appears to show that support *can* make a difference, as long as students productively use it.

6 CONCLUSIONS

The assistance dilemma is a fundamental challenge to learning scientists and educational technologists. Until we better understand how much guidance students need as they learn – and how to cater guidance to the prior knowledge level of students – we won't be able to appropriately design instructional software to best support student learning. This is especially so in domains and with software that are open ended, i.e., those that encourage exploration and inquiry.

The *VTG* software, a web-based inquiry-learning environment for learning about the theory of evolution, will allow us to experiment with different types of instructional support and provide an important data point in answering the assistance dilemma. We are in the process of finishing implementation of *VTG* and will soon conduct the full experiment described in section 4.1 with a fully implemented version of the program. The results of the study described in this paper encourage us that we will soon be able to more fully address our research questions.

ACKNOWLEDGEMENTS

This research is supported by a U.S. Department of Education, Institute Of Education Science Grant (Number R305A110021). We would like to thank other past and present members of the *VTG* project team–Donna Winston, Nick Matzke, Russell Almond, and Jerry Richardson–for their contributions to the development of *VTG*. *Voyage To Galapagos* was originally developed as a non-web-based program by the third author of this paper, Weihnacht, under National Science Foundation Award # 9618014.

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The Time Factor in MOOCS

Time-on-Task, Interaction Temporal Patterns, and Time Perspectives in a MOOC

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Keywords: MOOC, Temporal Patterns, Time Perspective, Time-on-Task, Lifelong Learning.

Abstract: MOOCs are a current trend in Higher Education; universities around the world offer open courses for lifelong and geographically distributed learners. Nevertheless, there is a high drop-out rate on these courses. The temporal aspects related to learner Temporal Perspectives (TP), self-regulation of learning, and temporal patterns could be related to drop-out rates and motivations for following a MOOC. This study aims to analyse student objective and subjective times in order to better understand their relationships with MOOC participation. The paper describes the case study methodology proposed to explore this relation: a pilot MOOC course on entrepreneurship (IE MOOC) with a total of 30 Catalan students who were active during the two-week course. The study examines the motivation and active participation of students in these learning methodologies, and practical issues on the schedule and temporal pace of MOOCs. Results show how student actions decrease as the MOOC progresses. Students connect more during weekdays and early and late evenings. They are mostly future-oriented, which is classically related to higher performance and self-regulation. This exploratory study shows how research on learners' temporal patterns could help to advance in the understanding of MOOC students' profile, in order to increase the currently low completion ratios.

1 INTRODUCTION

Massive Online Open Courses (MOOCs) can be defined as online courses with free and open registration, a publicly shared curriculum, and open-ended outcomes (McAuley, Stewart, Cormier and Siemens, 2010). MOOCs are one of the major educational trends of the last four years (Pappano, 2012; Pence, 2012) and offer Higher Education (HE) courses to a massive number of participants. These participants are often lifelong learning students and frequently have no access to other courses due to their work and personal commitments.

MOOCs offer the possibility of learning online to many students and are free of charge (Pappano, 2012). A massive number of participants can enrol in MOOCs from anywhere, overcoming the limitations of traditional face to face classrooms and existing online courses. MOOCs enable practically anyone to engage in virtual education and have the potential to provide education on a global scale. In particular, they can enable the massive development of knowledge and skills among those adult learners who have enough motivation, self-regulation, and cognitive quality time to engage and thus succeed in online courses.

Nevertheless, MOOCs are not currently comparable to other online and onsite university courses, especially in terms of evaluation, personalisation, and certification (Cooper and Sahami, 2013). This massive methodology implies important changes in the range of times involved in the course; that is, in terms of student objective times (time-on-task patterns, temporal zones, time availabilities) and subjective times (time preferences and time perspectives, among others); the tutors' or facilitators' time; and last but not least, in instructional time, which must suit a larger audience than classical online courses. Understanding the MOOC time factor challenges could help in understanding the high dropout rates, which some studies have estimated at around 85% (Rodriguez, 2012). Adult student time availability is one factor in student participation and completion of MOOCs.

Furthermore, students in MOOCs report a high drop-out rate and usually only seven or eight per cent complete courses (Clarke, 2013; Little, 2013), with the majority leaving the course (due to time constraints) after a few weeks if they are not motivated or interested in the content. Two-thirds of respondents in the study by Carr (2013) affirm they would be more likely to complete a MOOC if an accreditation certificate was given. According to Vogel (2012), student number figures claimed by MOOCs are highly speculative, and could include students who may have had little more than curiosity rather than a real commitment to learn. In their present form, MOOCs can be challenging for the learners because they demand a serious commitment in terms of time and effort and strict self-regulation (Little, 2013).

This paper aims to analyse various time factor implications of MOOCs from an instructional perspective, both for objective and subjective learner time, and based on an analysis of the case study of the Introduction to Entrepreneurship (IE) MOOC.

2 TIME FACTOR IN MOOCS

In education, time is an implicit factor that some approaches have tried to make explicit by defining typologies of academic time. Time is an important factor for understanding learning activities (Barberà, Gros and Kirschner, 2012), especially in active and online learning methodologies such as MOOCs, where students have a central role in course development and in regulating study time. Following McAuley, Stewart, Siemens, and Cormier (2010), a MOOC builds on the active engagement of several hundred or several thousand students who self-organise their participation. Although sharing some of the conventions of an ordinary course, such as a predefined timeline and periodic topics, a MOOC generally carries no predefined expectations for participation.

In the following sections we will first discuss objective time, based on the ALT model, and focusing on time-on-task by students, and then we will define this variable in MOOCs. We will then study the subjective or intrapsychological time related to learning and focus on the Time Perspective (TP) of learners as one of the factors classically related to learning achievement (Usart and Romero, 2014). Finally, we will outline the prevailing challenges for MOOCs: both for objective and subjective student time.

2.1 Objective Time

Time is one of the dimensions that society uses to measure objectively and synchronise individual, collaborative, and social activities. Learning needs time, and the educational system has been organised to organise times for formal learning. The measure of time in learning has been studied and defined through different models and theories. In this study, we consider the Academic Learning Times (ALT) model (Fisher et al. 1980; Harnischfeger and Wiley, 1985). (cf. Figure 1). ALT has been used in face-to-face and online learning contexts (Romero, 2010) and focuses on time from instructional and student perspectives. Within the ALT model, students can devote more or less time to the learning activity (engaged time or time-on-task) within the bounds of the time allocated by the teacher (allocated time). Within this time range, students have an amount of effective learning time.

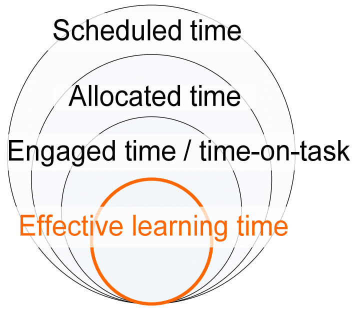

Figure 1: Academic learning times model.

The regularity and distribution of the different times can be observed as patterns. A temporal pattern refers to a structure appearing periodically within a given temporal rhythm, enabling the understanding of past events and anticipating future actions (Valax, 1986). Temporal patterns can be analysed at different levels of time such as the day, the week, and longer periods, such the duration of a learning activity of several weeks (Demeure, Romero, and Lambropoulos, 2010). The analysis of temporal MOOC patterns may help us understand student rhythms in these massive courses, and identify possible challenges such as high dropout rates.

In addition to the ALT categories, when technology is involved, we should also take into account the participants' e-competence and the complexity of the technology, and therefore consider the time required to learn how to use the learning technologies, which has been referred by McWilliams and Zilbermanfr (1996) as time of technology adoption.

2.1.1 MOOC Objective Time Challenges

Based on the ALT model, we can draw the temporal context for MOOCs. In a MOOC, scheduled time can be defined as the amount of time (usually weeks or even months) a course is open for users to access. However, MOOCs are by definition offered within a paced and time-dependent course model that could be limiting its supposed flexibility. The course structure represents a mix of open network models and traditional closed online models. If well designed, the speed and flexibility of MOOCs, together with ICT tools could help students interact without the constraints of space and time (McAuley et al., 2010).

After the first layer, allocated time can be measured as the changes in student objective time, understood both as the variety of time zones if students are geographically distributed; and their time availabilities as most students can only engage a few hours a day due to other commitments. Following McAuley, Stewart, Siemens, and Cormier (2010), individuals determine the extent of their own participation in a MOOC, defining their measure of success in the learning process. This apparent lack of schedules within the MOOC could turn against students if they lack self-regulation and do not know how to manage study time.

Changes in tutor time are also important. Being massive also demands a different role and time management system for the facilitator of the course. As McAuley et al., (2010) explain, although MOOC facilitators volunteer their time by guiding participants when necessary, it is expected that the other students will be the primary source of feedback during the course.

Finally, there are changes in the instructional time of the course needed to suit a large audience. Tasks and learning can take more time for students as they need to understand the rules and plan their own study. Furthermore, the time a student decides to invest in learning has been related to student engagement and motivation (Lewis, 2007; Wagner et al., 2008), two important assets that MOOC students hopefully acquire.

2.2 Subjective times

Human time is not only objective, but it also has a subjective dimension: intrapsychological time (Nuttin and Lens, 1985). This dimension of time is composed of individual variables related to the concept of time and how it is perceived. Three individual constructs are defined as the generators of psychological time: orientation to multitasking or polychronism; time orientation; and time perspective (TP; Zimbardo and Boyd, 1999). Polychronism is based on change and flexibility when attention is diverted among various possible activities, in contrast to monochronism (defined as the ability to concentrate on one activity at a time, with an emphasis on the development and adherence to schedules) (Hall and Hall, 1987). Polychronism is usually present in high-context cultures, where punctuality is less important, where flexibility and changes of activity are common and expected. Time orientation is described as being part of the wider TP context and is a one-dimensional trait that is independent of the situation or life domain.

Finally, TP is probably the aspect of psychological time that has been most related to learning processes and outcomes in formal education (Schmidt and Werner, 2007), and is defined as the manner in which individuals divide time into past, present, and future (Zimbardo and Boyd, 1999). In particular, they divide TP into 5 factors (see figure 2):

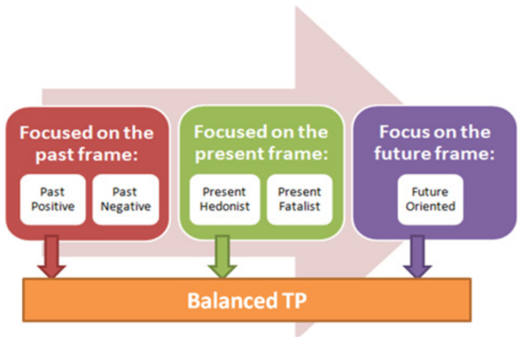

Figure 2: Time Perspective Factors.

These authors measured a correlation between higher education students and drop-out rates; present-oriented students tended to abandon university more than future-focused students. Furthermore, some authors have shown the relation between learners' future TP and learning achievement in e-learning (Usart and Romero, 2014); and also between future TP and self-regulation of learning by learners (de Bilde et al., 2011). Previous results show that, when learning activities are not compulsory, students with a high future TP tend to engage more in these learning tasks, as they foresee the future rewards of their present actions (Peetsma and Van der Veer, 2011). On the other hand, present-oriented students, in particular, present hedonists, tend to engage in social, instant-reward activities (Zimbardo and Boyd, 1999).

2.2.1 MOOC Subjective Time Challenges

Student TP has historically been studied in face-to-face contexts. There is a gap in the literature on the impact of TP on learning outcomes and processes in online learning (Usart and Romero, 2013). As MOOCs are based on different learning models, such as connectivism and constructivism (Brown, 2013; Siemens, 2009), and their participants have not always the self-regulation skills to be autonomous learners in MOOCs (Brown) it is important to study the temporal perspective of MOOC participants in order to understand the profile of adult entrepreneurship students enrolled in an open online course and study the possible relation with drop-out rates, learning achievement, self-regulation (Little, 2013), and motivation. Little, in the context of MOOCs, states that these courses can be challenging for learners because they demand a serious commitment in terms of time and effort, as well as strict self-regulation.

3 RESEARCH OBJECTIVES

To study both the temporal patterns of a MOOC and the temporal profile of students on these courses, we focussed on four aspects (hypotheses) of student objective and subjective times. Firstly, we posed a research question (RQ1) on student objective time. We aimed to study the temporal patterns of learners by focusing on three levels of interest: the global course (scheduled time); the day of the week (student time ties and self-regulation); and finally, the day periods (related to student time-on-task, self-regulation, and work and life bonds). MOOC temporal patterns are described and some aspects of student participation rates, both longitudinally and in terms of schedule, are quantitatively analysed.

RQ1: Which are the daily, weekly, and hourly patterns of the course?

The following hypotheses will help us specify this research question:

- H1. MOOC participants show a tendency to procrastinate as in face-to-face and e-learning programs (that is, we expect greater participation in the days nearer to the end of a task).
- H2. MOOCs are courses in which the participants are mainly lifelong learners who are professional adults with time constraints. We expect that students will participate more on weekends, when they have more leisure time, than during the weekdays, when they mostly work, as previously measured by Romero (2010).
- H3. MOOCS are aimed at adult participants with personal and professional ties, we expect that students will participate more during the late evenings than during the rest of day; nevertheless, we should keep in mind the large number of unemployed people in Spain, and this could influence results in this hypothesis.

We will also formulate a second research question (RQ2) to study learner subjective time, in particular, focusing on student TP. We have highlighted in the previous section that TP is usually related to diverse learning outcomes and individual differences such as self-regulation, and this is an important asset of MOOC students. To answer these questions, we conducted an exploratory study in the Introduction to Entrepreneurship (IE) MOOC.

RQ2: What is the TP profile of students in the IE MOOC?

- H4. We expect participants to be focused on future TP. This is due to the fact that existent literature on learning has related entrepreneurs and adult online student profiles with future TP as these students manage their time and are better self-regulated when studying.

4 METHODOLOGY

In this section we detail the case study methodology designed for analysing the objective and subjective times and their relationship with MOOC participation. Case studies are a research methodology attempting to examine a phenomenon in an authentic context. In particular, the real-life context chosen for analysing the MOOC participation in our study is an introductory course in entrepreneurship, the IE MOOC. In this section, the context of analysis of the IE MOOC course is described. We describe the study, the participants, and the main figures of the platform. Furthermore, we will focus on the specific methodologies for studying objective and subjective time factors, and the tools used for the quantitative analysis of objective and subjective time introduced in subsections 4.2 and 4.3.

4.1 Context of Analysis – MOOC in Entrepreneurship

The IE MOOC has been designed and implemented with the potentiality to be massive, but the first edition has had a total of 76 adults, registered through the IE MOOC form, available at a Google Site. The course has been only announced in the Catalan Chamber of Commerce for a month, which has limited the number of effective participants. Because the pilot nature of the IE MOOC, and its limited publicity, the number of participants does not allow to consider it as massive in terms of effective participation, but in terms of potentiality for future editions. We can refer to this MOOC as a "miniMOOC" in terms of Goldschmidt and Greene-Ryan (2013). Despite 76 Catalan participants registered this "miniMOOC", finally, 45 students accessed the LORE web of the course during the two weeks that the MOOC was active. There were 30 active participants during the two weeks of the course; 15 women and 15 men, with an average age of (M=31.8, SD=8.7). Only 13 participants completed the four mandatory activities proposed by the facilitators. Concerning their current occupation 5 of them declared to have an employment, and 2 of them admitted being unemployed. Because the question in relation to their occupation was not compulsory, the information of other participants' current status is missing. The proportion of unemployed participants in the IE MOOC (28%) is similar to the current unemployment rate in Spain, which has been estimated to be 26.7% according to EUROSTAT (October, 2013).

The IE MOOC was placed in the open platform LORE (www.lore.com), a web-based Virtual Learning Environment (VLE) that resembles a social network (see Figure 3). LORE was chosen because it looks like a social network and aims to help participants easily interact through the VLE, and also enables 'ICT non-experts' to create a MOOC. All the activities and references were accessible through the LORE discussion zone. The LORE platform initial studies allowed us to observe an irrelevant time of technology adoption (McWilliams, and Zilbermanfr, 1996) due to facility of use of the platform, and the normal to high level of e-competence of the participants enrolled in the IE MOOC.

The course schedule was divided into four topics: Topic 1, entitled *Presentation and Discussion*, was presented on the first day (Monday 13 May); Topic 2 was presented the same day to give faster students the opportunity make progress. The third topic was available on Tuesday, and the last topic on Wednesday. The course was active until the 23th May.

Figure 3: LORE discussion zone.

4.2 Methodology for Temporal Pattern Analysis

This study focuses on student participation during the whole course, therefore, it measures student activity both on the LORE platform and in the discussion zone; as well as measuring other tasks via the external logs from *Google forms* (for tasks 1, 2 and 5); and *LimeSurvey* data for task 3. Task 4 was reported by the students in the LORE platform. All time logs were recorded and prepared in an Excel file and analyzed with SPSS software.

The pace of the student actions was a relevant point: inside LORE students could post in the discussion zone, make (short) comments to posts, or press a 'like' button. Outside LORE, students had to perform different tasks and two serious games (completion of tests and game tasks). We therefore coded actions as *Post*, *Comment*, *Like* or *Task* outside LORE (P, C, L or T). In this study we did not differentiate among actions in the analysis, as the aim of our research questions and hypotheses is to study the activity and participation as a whole. These actions could be conducted during the 15 days of MOOC duration: the course started on 13 May and ended on 27 May. To analyse data and following Demeure, Romero, and Lambropoulos (2010) the comparison of the groups in the longitudinal activity level was conducted over three temporal periods: the beginning of the activity (days 1 to 5); the midterm of the activity (days 6 to 10); and the end of the activity (days 11 to 15). Secondly, these actions could be performed in a weekday or during the weekend, and finally, concerning the daily level, we follow the distribution used by Demeure, Romero and Lambropoulos, based on the Nie and Hillygus (2002) study, that divides the day into six time periods: night, early morning, late morning, afternoon, early evening and late evening. Thus, the times of these six periods are defined according to a standard working day: night for 2 am to 5 am; early morning for 6 am to 9 am; late morning for 10 am to 1 pm; afternoon for 2 pm to 5 pm; early evening for 6 pm to 9 pm; and late evening from 10 pm to 1 am.

4.3 Methodology for TP Analysis

The analysis of the student TP was conducted using the Zimbardo Time Perspective Inventory (ZTPI; Zimbardo and Boyd, 1999). This instrument presents 56 statements for the five theoretically independent factors described by Zimbardo and Boyd (Past Positive, Past Negative, Present Hedonism, Present Fatalism and Future). Each statement is rated using a 5-point Likert scale (1 = strongly disagree, and 5 = totally agree). Following these authors, individuals tend towards one of the five orientations or have a balanced TP. The Spanish version of the ZTPI was implemented in topic 3, as part of the MetaVals task. This instrument was previously validated through a psychometric study conducted by Díaz-Morales (2006) on a reliable sample of Spanish adults (N= 756) and was used in the present study to ensure consistency with the theoretical approach of the chosen TP definition.

5 RESULTS

A total of 30 students participated actively, and performed a total of 209 actions during the course. To study the H1, we focused on time patterns at a course level, operationalized as the number of student mean activities per day from 13 Monday to 27 Monday independently of the hour or day of week. By dividing the course into start, middle, and end (Demeure, Romero and Lambropoulos, 2010) we can observe from Figure 3 how participants showed a significant decrease in activity. We conducted a within subject ANOVA of each participant during the 15 days of the course, divided into three parts. Results show a significant difference between the last five days (M = 0.57, SD = 1.16) compared to the first (M = 3.07, SD = 2.80) and the second course periods (M = 2.63, SD = 3.31) [F (2,87) = 7.97, p = .001] .

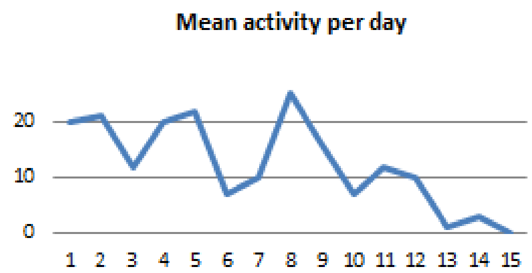

Figure 4: Students mean activity during the 15-day MOOC.

H2 aimed to study temporal pattern differences between the different days of the course. To explore more specifically the difference between weekdays and the weekend, we conducted a within subject ANOVA on the basis of the participation average of each participant during weekdays and weekends. Results show that participants in the IE MOOC tend to work more during weekdays, in particular Monday (M = 1.67, SD = 1.92), than during the weekend (M = 0.40, SD =0.96) [F(6,203) = 2.86, p = .011] .

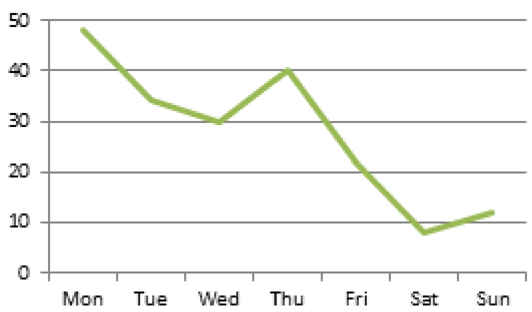

Figure 5: Participant actions per weekday.

H3 focuses on day periods. Differences among day periods were not found to be significant in the ANOVA study. However, students in the IE MOOC tended to participate more in late morning (M = 0.70, SD =0.84) and late evening (M = 0.67, SD =0.88) and less at night and early morning [F(5,174) = 2.15, p = .061]. Figure 6 shows results for this hypothesis.

H4: Student TP:

Only 12 students from the 30 active in the MOOC completed the ZTPI test. Of these students eight (66.67%) were future-oriented, two students were past negative (16.67%), one as past-positive, and another as present-hedonist. No students were classified as present-fatalists. Furthermore, all the participants had a high score in FTP (>3.3). The average TP pattern for the students in the IE MOOC can be seen in the figure below.

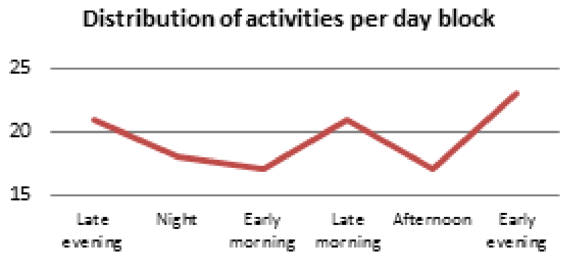

Figure 6: Student task distribution during the day.

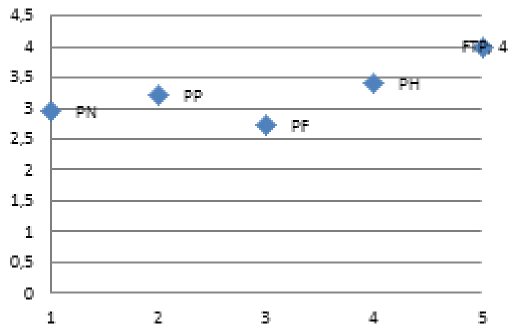

Figure 7: Student average TP.

6 DISCUSSION

Results for the course longitudinal activity (H1) show a significant decrease in the mean activity for IE MOOC students. This enables us to affirm that, following Clarke (2013), students tend to lose motivation during the course. Nevertheless, taking a look at the scheduled activities and the content of the facilitator messages, we can see that the 'day 8' peak is probably due to the reminder issued in the LORE forum of the MOOC rules. This course was designed with a gamification approach (Romero and Usart, 2013) that enabled participants to add scores to their task results, and finally win a competition within the MOOC. Course designers aimed to foster participation with this contest, and, from the quantitative results (Figure 4) students peaked when they were reminded of these rules. To the best of the authors' knowledge, no previous studies have focused on the quantitative analysis of this longitudinal pattern in MOOCs. However, following the Demeure, Romero and Lambropoulus (2010) study in e-learning tasks, a tool that could help students in a group to become acquainted with each other (such as the LORE discussion zone and presentation) could enhance the time allocated to the learning task itself, and thus improve e-learner performance and leveraging procrastination. This is consistent with our results.

Finally, as Carr (2013) showed, some students need a final accreditation in MOOC to further their participation in the course. The implementation of a contest or gamification could be another solution for this issue, as the results for longitudinal participation demonstrate in our case. Some researchers claim there is a need to develop interactive MOOCs to engage learners and keep them sufficiently interested during the whole course to complete it. Little (2013) suggests the inclusion of games or simulations to help students engage in these learning environments.

Concerning the differences among weekday and weekends (H2), we have shown that students tend to participate significantly more on Mondays, as it coincides with the MOOC starting day, and on Thursdays, when students were reminded of the rules of the course by the facilitators. Furthermore, weekends show lower participation rates, contrary to what could be expected for lifelong learners, and students prefer to spend their weekends in other activities and study while they work during the week. This is in accordance with Romero's (2010) results that students in adult e-learning activities use their residual time to work on learning tasks. As the author reports, helping students to organise themselves in other life aspects could help them to free better quality time for the learning task; but this is not the focus of our study.

In light of the results from day period analysis (H3), we have observed a higher activity ratio in early and late evening, despite the results are not statically significant. Linking this to previous hypothesis results (weekends are not used by learners), we can relate this to the fact that students are lifelong adult learners who have work and family commitments during the 'conventional' time of the day, and take advantage of other time periods to engage in learning activities such as the MOOC. Nevertheless, there is a peak of activity in the late morning that seems to be in accord with Demeure, Romero and Lambropoulus (2010). Students could be using their job-breaks during lunch time to connect to the MOOC, but it is also possible that some students are unemployed and study all the day. A possible solution to the reported daily and weekly time constraints could be mobile access to MOOCS. As de Waard and colleagues (2011) state, participants in MOOCs indicate that they prefer to use their mobile devices to access course materials because they can participate whenever they wish, that is, they positively evaluate temporal independence. In our case, students could make posts, post short comments, or post likes to other comments via Smartphones.

H4. Student TP was highly oriented to the future, and this factor was high even in students with other perspectives. This can be explained in face-to-face learning activities; students with a high future TP usually engage in the learning process and are more active (Peetsma and Van der Veer, 2011) because they care about the future implications of their investment in study. Following Clarke (2013), MOOCs build on the engagement of learners who self-organise their participation according to learning goals, and prior knowledge, skills, and common interests.

Future TP students showed a higher academic engagement (Fourez, 2009). Furthermore, these temporal profiles are correlated with self-regulated learners (de Bilde, Vansteenkiste, Lens, 2011), and we have seen that a MOOC demands high levels of self-regulation to succeed in an open learning context where there is little direction by the facilitator – and much of the learning is provided by interaction with peers. The fact that no present-fatalist students completed the ZTPI could be related to their profile characteristics; individuals with a fatalist TP tend to be passive and less engaged in learning as they believe the future is written (Zimbardo and Boyd, 1999). Finally, the fact that only one present-hedonist student was found in the sample could agree with Zimbardo and Boyd's results among undergraduate students: present-hedonists show higher drop-out rates due to their lack of consideration of future consequences.

The results of the case study show the challenge integrating lifelong learning to the already complicated equation of Work Life Balance (WLB). We observed that the learners of the IE MOOC use their evenings for participating in the course and the first days of the weekdays when returning to their daily routines. When considering their TP, we observe a better engagement of future oriented students, a result that should be taken into consideration in order to promote social activities where future oriented students are mixed to other TP students to promote their engagement.

7 CONCLUSIONS

MOOCs offer a new approach for lifelong adult learners who aim to pursue a course with fewer time and space constraints than classic face-to-face and online courses. However, this methodology demands high levels of self-regulation and commitment. We have studied objective and subjective learner temporal patterns. Results show a continuing decline in activity during the whole course, probably because personal and work bonds do not allow students enough time. Students increase their level of activity when reminded of the rules of the MOOC in a gamification context. This could be very useful for engaging students during this period. Time during the week and within a day was analysed quantitatively. Students prefer to access the MOOC at night and connect less on weekends. This aspect should be further studied, as we suggest that night time study may be of poor quality and students should be helped to connect at weekends. Finally, students show a clear future orientation; this is in accordance with previous studies on learning and TP; students who are focused on the future tend to be more self-regulated, and invest more time studying in expectation of future benefits. We recommend MOOC designers learn about the TP of their audience and thus design more active and 'mobile' MOOCs that could help students with present or past-perspectives engage in the MOOC with an instant-reward activity. The number of participants of this first edition of the IE MOOC entails some limits to the external validity towards other MOOC studies. Nevertheless, this "miniMOOC" study has advanced in the methodology of the analysis of the time factor in MOOCs, and opened the possibilities for extending this study in future editions of the course. More research is needed in the field of time factor in MOOC contexts. In particular, qualitative analysis and focus on the types of actions (posting a *like* in LORE does not demand the same effort as making a long presentation post or task) could give us more details about the temporal patterns of participants and the quality of their time spent learning.

ACKNOWLEDGEMENTS

This study was developed within the context of two European projects, entrepreneurship and Serious Games (eSG project) and the Network of Excellence FP7 Games and Learning Alliance (GaLA), in the

Special Interest Groups of Pedagogy and Psychology.

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Efficiency of LSA and K-means in Predicting Students' Academic Performance Based on Their Comments Data

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Keywords: Freestyle Comments, PCN Method, LSA, K-means Cluster Algorithm.

Abstract: Predicting students' academic performance has long been an important research topic in many academic disciplines. The prediction will help the tutors identify the weak students and help them score better marks; these steps were taken to improve the performance of the students. The present study uses free style comments written by students after each lesson. These comments reflect their learning attitudes to the lesson, understanding of subjects, difficulties to learn, and learning activities in the classroom. (Goda and Mine, 2011) proposed PCN method to estimate students' learning situations from their comments freely written by themselves. This paper uses C (Current) method from the PCN method. The C method only uses comments with C item that focuses on students' understanding and achievements during the class period. The aims of this study are, by applying the method to the students' comments, to clarify relationships between student's behaviour and their success, and to develop a model of students' performance predictors. To this end, we use Latent Semantic Analyses (LSA) and K-means clustering techniques. The results of this study reported a model of students' academic performance predictors by analysing their comment data as variables of predictors.

1 INTRODUCTION

The topic of explanation and prediction of students' academic performance is widely researched. The ability to predict their performance is very important in educational environments. Increasing students' success is a long-term goal in all academic institutions. If educational institutions can predict their academic performance before their final examination as early as possible, extra efforts can be taken to arrange proper support for them, in particular lower performance students to improve their studies and help them success. Many researchers tried to predict students' behaviors in educational environments based upon diverse factors like personal, social, psychological, and other environmental variables. Various experiments have been carried out in this area.

This paper also proposes a method for predicting students' grades. Unlike previous studies, our method is based on students' freestyle comments collected in their class. The students' comments are good resources to predict their learning situations. Each student writes his/her comments after a lesson; the student looks back upon his/her learning behavior and situation; he/she can express about his/her attitudes, difficulties, and any other information that help a teacher estimate his/her learning activities.

(Goda and Mine, 2011) proposed the PCN method to estimate students' learning situations from freestyle comments written by the students. The PCN method categorizes the students' comments into three items of **P** (Previous activity), **C** (Current activity), and **N** (Next activity). It provides data expressing students' learning status, also index reducing the task for all of their self-observations, self-judgments, and self-reactions. However (Goda and Mine, 2011) did not discuss prediction of students' grades.

In this paper we propose a prediction method of students' grades using comments with C item (C comments in short). Our proposed method is as follows:

- We analyzed C comments by using Mecab program*, which is a Japanese morphological analyzer to extract words and their part of speech (verb, noun, adjective, and adverb).
- We applied LSA to extracted words and comments matrix so that we can identify patterns and relationships between the extracted words and latent concepts contained in unstructured collection of texts (students' comments).
- We classified the results of LSA into 5 groups by using K-means clustering method.

The rest of the paper is organized as follows: Section 2 summaries related work in an application of prediction of students' performance by data or text mining techniques in educational environments; Section 3 describes our students' grade prediction method, explaining related methods such as LSA and K-means clustering algorithm; Section 4 discusses experimental results of students' final grade predictions. Finally, we conclude this paper with a summary and describe an outlook for future work.

2 RELATED WORK

The main objective of any higher educational institution is to improve the quality of managerial decisions and to impart quality education. Good prediction of student's success in higher learning institution is one way to reach the highest level of quality in higher education systems.

Various experiments have been carried out in this area to predict students' academic performance. To predict students' marks in the end of their semester, (Bharadwaj and Pal, 2011a) used the students' marks of their previous semester, test grade in their previous class, seminar performance, assignment performance, general proficiency, attendance in their class and lab work. (Bharadwaj and Pal, 2011b) also conducted another study on students' performance, selecting 300 students from 5 different degree colleges in India. They found that students' academic performance were highly correlated with their grades in senior secondary exam, living location, medium of teaching, mother's qualification, family annual income, and their family status. Using students' attendance, test grade in their class, seminar and assignment marks, and lab works, (Yadav et al., 2011) predicted their performance at the end of the semester with help of three decision tree algorithms: ID3, CART, and C4.5, and achieved 52.08%, 56.25%, and 45.83% classification accuracy, respectively. (Kovacic, 2010) used students' enrollment data to predict successful and unsuccessful student in New Zealand, and achieved 59.4% and 60.5% of classification accuracy when using decision tree algorithms: CHAID and CART, respectively. (Sembiring et al., 2011) found that students' interest, study behaviour, learning time, and family support are significantly correlated with their academic performance. (Osmanbegović and Suljić, 2012) applied three supervised data mining algorithms (Naïve Bayes, neural network, decision tree) to the preoperative assessment data, to predict students' pass or failure in a course; They evaluated prediction performace of the learning methods based on their predictive accuracy, ease of learning, and user friendly characteristics. The results indicated that the Naïve Bayes classifier outperforms, on its predictive accuracy, decision tree and neural network methods. (Kabakchieva, 2013) focused on the implementation of data mining techniques and methods for acquiring new knowledge from data collected by universities. The main goals of the research are to reveal the high potential of data mining applications for university management, to find out if there are any patterns in the available data that could be useful for predicting students' performance at the university based on their personal and pre-university characteristics. Kabakchieva classified students' level into five distinct categories (excellent, very good, good, average, and bad); they were determined from the total university score achieved by the students. The experimental study classified data by decision tree algorithm (C4.5 and J48), Bayesian classifiers (NaiveBayes and BayesNet), a Nearest Neighbour algorithm (IBk) and two rule learners (OneR and JRip). The results indicated that the prediction rates were not remarkable (vary between 52 and 67%). Moreover, the classifiers perform differently for the five classes. The data attributes related to the students' university admission score and number of failures at the first-year university exams are among the factors influencing most the classification process. (Adhatrao et al., 2013) built a system to predict students' performance from their previous performances using concepts of data mining techniques under classification. They analyzed the data set containing information about the students, such as gender, marks scored in the board examinations, marks and rank in entrance

* http://sourceforge.net/projects/mecab/

examinations and results in the first year of the previous batch of the students. They applyed ID3 and C4.5 classification algorithms, and predicted the general and individual performance of freshly admitted students in future examinations. The accuracy result is 75.15% for both ID3 and C4.5 algorithms. (Antai et al., 2011) classified a set of documents according to document topic areas by using CLUTO program with and without LSA. The results showed that the internal cluster similarity with LSA was much higher than that without LSA.

According to the previous studies mentioned above, external data beside students' marks in the previous year are important to predict their performance. On the other hand, using suitable data mining techniques related to input data will give better results than others.

(Bachtiar et al., 2012) developed an estimation model to predict students' English ability (listening, reading, speaking, and writing) skills and performance. They proposed a questionnaire to quantify students' affective factors with three major factors: motivation, attitude, and personality. The components of each of these factors are further identified by exploring each factor conceptually. They applied a neural network model in their experiments. The accuracy scores obtained by the model were 93.3% for listening, 94.4% for reading, 94.9% for speaking, and 93.6% for writing skills. (Minami and Ohura, 2013) analysed students' attitude towards learning, and investigated how it affects their final evaluation; they pursued a case study of lecture data analysis in which the correlations between students' attitude to learning such as attendance and homework as effort, and the students' examination scores as achievement; they analyzed the students' own evaluation on themselves and lectures based on a questionnaire; they also introduced a new measuring index named self-confidence, to investigate the correlations between self-confidence, self-evaluation, lecture evaluation, effort, and achievement scores. Through this study, they showed that a lecturer can give feedback data to students who tend to over-evaluate themselves, and let the students recognize their real positions in the class.

From the two studies, we need to understand individual students more deeply, recognize students' learning status and attitude to give feedbacks to them. Although applying questionnaire gave good results than previous data (e.g. personality, sociality, and students' behaviour), we need to understand students' characteristics more deeply by letting them describe themselves about their educational situations such as understanding of subjects, difficulties to learn, learning activities in the classroom, and their attitude toward the lesson. Researchers have used various classification methods and various data in their studies to predict students' academic performance.

Different from the above studies, (Goda and Mine, 2011) proposed PCN method to estimate students' learning situations with their freestyle comments written just after lesson. The PCN method categorizes their comments into three items: **P** (Previous), **C** (Current), and **N** (Next) so that it can analyze the comments from the points of views of their time-oriented learning situations. (Goda et al., 2013) proposed PCN scores for determing the validity level of assessment to students' comments and showed there exist strong correlations between the PCN scores and accuracy of predicting students' final grades. First, they employed multiple regression analysis to calculate PCN scores and the results indicated that students who wrote comments with high PCN scores are considered as those who describe the students' learning attitude appropriately. Second, they applied machine learning method Support Vector Machine (SVM) to the comments for predicting the students' final results in five grades of S, A, B, C, and D. The experimental results illustrated that as students' comments get higher PCN scores, prediction performance of the students' grades becomes higher. Goda et al., however, did not discuss prediction performance of students' final grades.

In this study, as an extention of (Goda et al., 2013), we focus on prediction performance of students' final grades. Using C comments from PCN method, we try to predict their grade in each lesson and discuss change of accuracy in a sequence of the lessons.

In the following section, we describe our method for predicting students' performance.

3 STUDENTS' GRADE PREDICTION METHOD

3.1 Overall Procedures of Proposed Method

Figure 1 displays the overall procedures of our proposed method; we have five phases:

1- Comments Data Collection: This phase focuses on collecting comments from students after each lesson. In this case, we use comments data

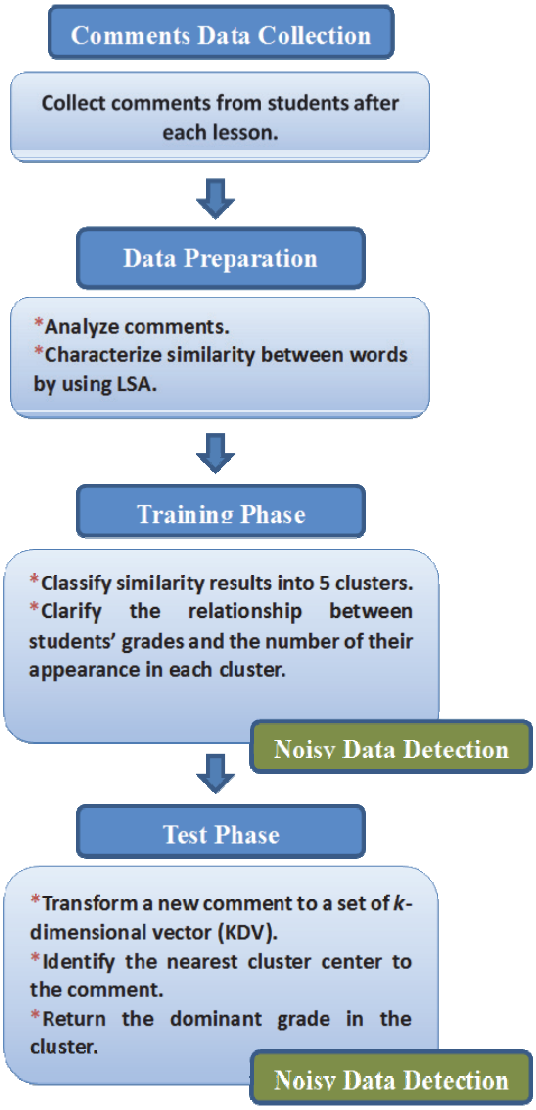

Figure 1: Overall procedures of the proposed method.

collected previously from (Goda and Mine, 2011). We choose C comments that describe the current activities of the students during the class period. (See Section 3.2)

2- Data Preparation: The data preparation phase covers all the activities required to construct the final dataset from the initial raw data. Our method analyses comments data by extracting words and part of speech, calculating the word frequencies, applying log entropy weighting method so as to balance the effect of occurrence frequency of words in all the comments (See Section 3.3), and applying LSA technique to reduce the dimensions of a matrix and obtain the most significant vectors. (See Section 3.4)

3- Training Phase: In this phase, we classify LSA results into 5 clusters by using K-means clustering method. (See Section 3.5)

4- Test Phase: This phase revolves on extracting words from a new comment, and transforming an extracted-words vector of the comment to a set of k-dimensional vector (KDV) by using LSA.

We identify the nearest cluster center to the comment, among the 5 clusters created in the training phase, and return the dominant grade in the cluster. (See Section 4)

5- Noisy Data Detection: we detect noisy data from the points of view of grade prediction. We conduct the detection in two phases: training phase and test phase. In the training phase, we calculate Standard deviation (***Sd***) to each cluster. In the test phase, we measure the average distance between a new comment and cluster centers. (See Section 3.6)

3.2 PCN Method and Students' Grade

Goda collected free-style comments of 123 students in two classes who attended his programming exercise course. The course had 15 lessons and the students' comments were collected every lesson (Goda and Mine, 2011).

Each student described his/her learning tendency, attitudes, and understanding for each lesson. Goda prepared the fill in forms for their comments. The form consists of four items: P, C, N and O. The explanations of the items are shown in Table 1.

Table 1: Viewpoint Categories of Students' Comments.

Viewpoint	Meaning
P (Previous)	The learning activity before the class time such as review of previous class and preparation for the coming class. For example, "I read chapter 3 of the textbook."
C (Current)	The understanding and achievements of class subjects during the class time. For example, "I didn't finish all exercise because time is up."
N (Next)	The learning activity plan until the next class. For example, "I will make preparation by next class."
O (Other)	Other descriptions

The main idea of their research was to grasp students' learning status in the class, and illustrate the validity of the PCN method.

In their another study, (Goda et al., 2013) proposed PCN score to judge the appropriateness of students' comments and the way to automatically calculate the score with high accuracy; they also showed there exist strong correlations between the PCN score and prediction performance of students' grades by applying SVM to their comments. They chose five grades instead of mark itself as students' results. Table 2 shows the correspondence between the grades and the range of marks in the exam. The results of their method are shown in Table 3, where C comments get higher results at the head of grades: S, A, and B, compared with P and N comments.

In this research, we have chosen C comments from (Goda et al., 2013); C comments show understanding and achievements of class subjects during the class time as shown in Table 1.

Table 2: The correspondence between grades and the range of marks.

Grade	Scores
S	90-100
A	80-89
B	70-79
C	60-69
D	0-59

Table 3: Correlation Coefficient of PCN-score and student grades (Goda et al., 2013).

	P	C	N
S	0.3356	0.7956	0.6700
A	0.2647	0.8624	0.7829
B	0.7465	0.8263	0.7076
C	0.7631	0.6602	0.5380
D	0.7355	0.4955	0.2079

3.3 Term Weighting to Comments

After choosing C comments, we use a Japanese morphological analyzer Mecab to analyze each sentence for extracting words and their part of speech (noun, verb, adjective, and adverb).

In preparing for LSA, the text is modeled in a standard word-by-comment matrix (Salton and McGill, 1983) by extracting words from the natural language text. We follow procedures established for extracting keywords from the comments. This word-by-comment matrix *A* shown in Table 4 is comprised of *m* words $w_1, w_2, \ldots, w_i, \ldots, w_m$ in *n* comments $c_1, c_2, \ldots, c_j, \ldots, c_n$, where the value of each cell a_{ij} of *A* represents a local term frequency tf_{ij} that indicates the number of occurrence of word "w_i" in comment "c_j." To balance the effect of word frequencies in all comments, log entropy term weighting method is applied to the original word-by-comment matrix, which is the basis for all subsequent analyses (Botana et al., 2010); we apply a global weighting function to each nonzero element of a_{ij} of *A* to improve retrieval performance.

The global weighting function transforms each cell a_{ij} of *A* to a global term weight g_i, which is entropy of w_i for the entire collection of comments (Landauer, T., et al., 2013 & Dumais, 1991).

Here, g_i is calculated as follows:

Global Term Weight g_i	$g_i = 1 + \Sigma_{j=1,n} (p_{ij} \log (p_{ij}) / \log (n)$ where $p_{ij} = L_{ij} / gf_i$, $L_{ij} = \log (tf_{ij} + 1)$; tf_{ij} is the number of occurrence of w_i in c_j, gf_i is the number of occurrence of word w_i in all comments, and n is the number of all the comments.

Table 5 shows the results generated after applying log entropy weighting method, where the rows refer to words, and columns refer to C comments.

Table 4: Word by comment matrix.

Word	Com 1	Com 2	Com 3	Com 4	Com 5	Com6	Com 7	Com 8
Level	1	0	1	0	1	1	0	1
Setting	0	1	0	1	0	0	0	1
Understand	1	0	0	1	0	0	1	1
Do	1	0	0	0	0	1	0	0
Opertion	0	1	0	1	0	1	0	0
Exist	0	0	1	0	0	0	1	1
Connection	1	0	0	1	0	0	1	1
Suffer	0	0	0	0	0	0	0	0
What	0	1	0	0	1	0	1	0
Screen	0	0	1	0	0	0	1	0
Treatment	1	0	0	1	0	0	1	0

Table 5: An example of log entropy term weighting.

Word	Com 1	Com 2	Com 3	Com 4	Com 5	Com6	Com 7	Com 8
Level	0.45	0	0.45	0	0.45	0.45	0	0.45
Setting	0	0.71	0	0.71	0	0	0	0.71
Understand	0.58	0	0	0.58	0	0	0.58	0.58
Do	0.99	0	0	0	0	0.99	0	0
Opertion	0	0.71	0	0.71	0	0.71	0	0
Exist	0	0	0.99	0	0	0	0	0.99
Connection	0.58	0	0	0.58	0	0	0.58	0.58
Suffer	0	0	0	0	0	0	0	0
What	0	0.71	0	0	0.71	0	0.71	0
Screen	0	0	0.99	0	0	0	0.99	0
Treatment	0.71	0	0	0.71	0	0	0.71	0

3.4 Latent Semantic Analysis

LSA has been defined in different ways by different researchers. (Dumais, 1991) defined LSA as a statistical information retrieval technique, designed for the purpose of reducing the problems of synonymy and polysemy in information retrieval. LSA is also defined as a theory and method for extracting and representing the contextual-usage meaning of words by statistical computations applied to a large corpus of text (Landauer and Dumais, 1997). The underlying idea is that the aggregate of all the word contexts in which a given word does and does not appear provides a set of mutual constraints that largely determine the similarity of meaning of words and sets of words to each other. The mathematical foundation for LSA lies in singular value decomposition (SVD), which is a matrix approximation method for reducing the dimensions of a matrix to the most significant vectors. Here we assume matrix A of dimension m×n, where m is the total number of words, and n is the total number of comments, is defined as $A=USV^T$, where U (m×n) and V^T (n×n) are the left and right singular matrices (orthonormal) respectively, and S (n×n) is the diagonal matrix of singular values. SVD yields a simple strategy to obtain an optimal approximation for A using smaller matrices. If the singular values in S are ordered descending by size, the first k largest may be kept and the remaining smaller ones set to zero. The product of the resulting k-reduced matrices is a matrix $A^{\tilde{}}$, which is approximately equal to A in the least squares sense and of the same rank. That is, $A^{\tilde{}} \approx A = USV^T$ (Berry et al., 1995). A pictorial representation of the SVD of input matrix A and the best rank–k approximation to A can be seen in Figure 2. The baseline theory for LSA in text processing is that by looking at the entire range of words chosen in a wide variety of texts, patterns will emerge in terms of word choice as well as word and document meaning.

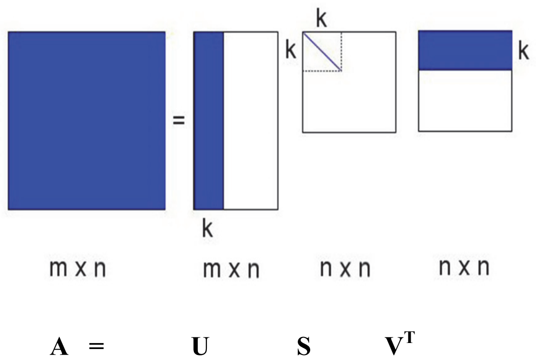

Figure 2: Diagram of the truncated SVD, the blue colour illustrates how to reduce the range of data (Berry et al., 1995; Witter and Berry, 1998).

The number of singular dimensions to retain is an open issue in the latent semantic analysis literature. Based on the research (Hill et al., 2002) retaining dimensions 2 to 101 resulted in satisfactory performance.

In this research, we apply LSA to the word by comment matrix as shown in Table 6, and retaining only the first four ranks by keeping the first four columns of U, V, and S.

Table 6: Results of k dimensional vector (KDV).

$$A^{\tilde{}} = \begin{vmatrix} 0.649 & 0.733 & 0.263 & 0.073 \\ 0.926 & 0.977 & 0.783 & 0.701 \\ 0.489 & 0.465 & 0.357 & 0.241 \\ 0.521 & 0.544 & 0.434 & 0.381 \\ 0.543 & 0.551 & -0.217 & 0.176 \\ 0.275 & 0.291 & 0.375 & 0.249 \\ 0.496 & -0.469 & 0.502 & 0.007 \\ 0.423 & 0.426 & 0.347 & 0.138 \\ 0.583 & 0.571 & -0.43 & 0.307 \\ 0.445 & 0.444 & 0.308 & 0.219 \\ 0.398 & 0.404 & -0.384 & 0.2 \\ 0.64 & -0.658 & -0.328 & 0.121 \\ 0.443 & 0.433 & 0.512 & 0.374 \end{vmatrix}$$

3.5 Clustering

One of the definitions given of clustering by (Zaiane,1999), is a process in which a set of objects are split into a set of structured sub-classes, bearing a strong similarity to each other, such that they can be safely treated as a group. Such sub-classes are referred to as clusters. (Csorba and Vajk, 2006) define document clustering as a procedure which is used to divide documents based on certain criterion, like topics, with the expectation that the clustering process should recognize these topics and subsequently place the documents in the categories to which they belong. Various clustering algorithms, which work in different ways, have been proposed. In this research, we concern with K-means clustering algorithm, which is one of the simplest unsupervised learning algorithms. We classify k dimensional vector (KDV) results into 5 groups, then carry out test by comparing clustering results with students' grades. Figure 3 shows how to make clusters from the data based on 5 grades.

Next, we consider to make clusters of students' comments collected at each lesson from 7th to 15th. 104 C comments are collected at the 7th lesson. The number of words extracted after analysing comments are 486 for the lesson.

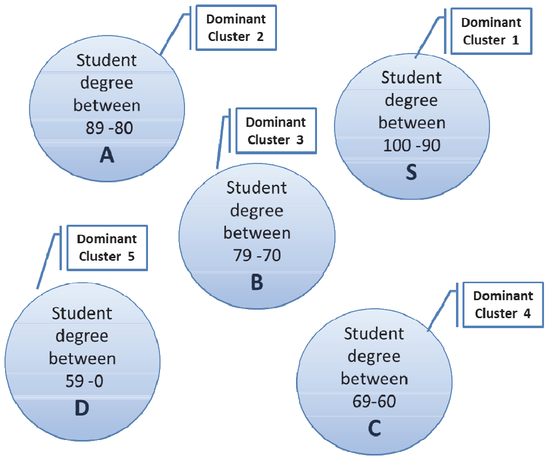

Figure 3: An example of clustering data based on students' grades: S, A, B, C, and D.

The results in the training phase are shown in Table 7. Grade S accounts for about 54% in Cluster 1; grade A about 61% in Cluster 2; grade B about 43% in Cluster 3; grade C about 45% in Cluster 4; finally, grade D about 53% in Cluster 5. Here we call the grade that most frequently appears in a cluster, *dominant grade* in the cluster; dominant grades in Cluster 1, 2, 3, 4, and 5 are S, A, B, C, and D, respectively.

Table 7: The results of training phase for lesson 7.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
S	0.54	0.08	0.09	0.15	0
A	0.22	0.61	0.26	0.25	0.27
B	0.14	0.14	0.43	0.10	0.07
C	0.10	0.17	0.09	0.45	0.13
D	0	0	0.13	0.05	0.53

3.6 Noisy Data Detection

Outlier detection discovers data points that are significantly different from the rest of the data. In text mining, outlier analysis can be used to detect data that adversely affect the results (Mansur et al., 2005). In this paper, we detect outliers in two phases: training phase and test phase. We call such outliers noisy data from the points of view of grade prediction.

3.6.1 Noisy Data Detection in Training Phase

In the training phase, we calculate Standard deviation (*Sd*) to each cluster to detect noisy data.

The calculation of *Sd* is as follows:

1. For each cluster, say *i*th cluster, calculate the centroid c_i of the cluster by finding the average value of KDV formed comments in the cluster.

$$c_i = \frac{\sum_{k=1}^{n_i} s_{k,i}}{n_i} \qquad (1)$$

Here $s_{k,i}$, and n_i are the *k*th singular vector representing a comment and the number of the comments in the *i*th cluster, respectively.

2. Calculate the standard deviation for the cluster.

The higher the Sd_i is, the lower the semantic coherence is (Dhillon et al., 2001). Here, we define noisy data of the *i*th cluster in training phase as follows:

$$Sd_i = \sqrt{\sum_{k=1}^{n_i} (s_{k,i} - c_i)^2 / n_i} \qquad (2)$$

Noisy Data in the *i*th Cluster in Training Phase:
Let $s_{k,i}$ be the *k*th member of the *i*th cluster;
if $s_{k,i} > Sd_i$, then $s_{k,i}$ is a noisy data of the cluster, otherwise $s_{k,i}$ is not a noisy data of the cluster.

3.6.2 Noisy Data Detection in Test Phase

In the test phase, we calculate the average distance between a new comment and a cluster center to detect noisy data. We define noisy data of the *i*th cluster in test phase as follows:

Noisy Data in the *i*th Cluster in Test Phase:
Let c_i, $s_{k,i}$, and $d_{i,ave}$ be the center of the *i*th cluster, the *k*th member of the cluster, and the average distance between members of the cluster and c_i, respectively;
if $|s_{k,i} - c_i| > d_{i,ave}$, then $s_{k,i}$ is a noisy data for the cluster, otherwise $s_{k,i}$ is not a noisy data for the cluster.

3.6.3 Effect of Removing Noisy Data

Here we show the effect of noisy data detection in the training phase. Such the effect in test phase will be described in the next section.

Table 8 displays the result after detecting noisy data for lesson 7. They become better than before,

Table 8: The results of training phase after removing noisy data.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
S	0.66	0.14	0.07	0.13	0
A	0.13	0.72	0.27	0.02	0.13
B	0.13	0	0.47	0.26	0.16
C	0.08	0.14	0.06	0.59	0.13
D	0	0	0.13	0	0.58

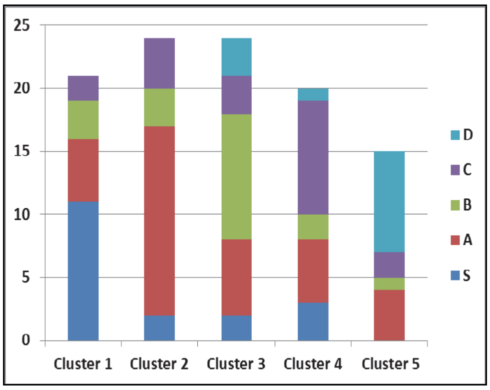

Figure 4: K-means cluster for training data at lesson 7 before detecting noisy data.

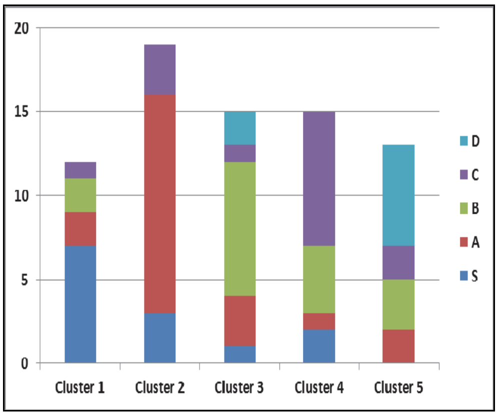

Figure 5: K-means cluster for training data after removing noisy data.

especially in cluster 1, 2, and 4. Figures 4 and 5 illustrate results before and after detecting noisy data in training phase, respectively.

4 PREDICTION PERFORMANCE

In order to predict a student's grade based on his/her comments, we established the following steps:

1. Extract words from a new comment.
2. Transform a comment to a set of k-dimensional vector (KDV) by calculating the following equation.

$$q' = q^T U_k S_k^{-1} \quad (3)$$

Here q and q' are the vector of words in a new comment multiplied by the appropriate word weights and the KDV transformed from q, respectively. The sum of these k dimensional word vectors is reflected by the term $q^T U_k$ in the above equation. The right multiplication by S_k^{-1} differentially weights the separate dimensions (Rosario, 2000).

3. Identify which cluster center is the nearest to the comment, by measuring the distance between the comment and cluster centers.
4. Return the dominant grade in the cluster to which the identified cluster center belongs, where the dominant grade in a cluster means the grade that most frequently appears in the cluster as described in the explanations of Table 7.

After performing the above steps, we conducted 10-fold cross validation. Table 9 and Figure 6 present the results of students' grade prediction: (Cluster1, S=53%), (Cluster 2, A= 54%), (Cluster 3, B=52%), (Cluster4, C=63%), (Cluster 5, D=47%).

Table 9: The results in test phase for lesson 7 before detecting noisy data.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
S	0.53	0.19	0.10	0.05	0.06
A	0.11	0.54	0.14	0.09	0.18
B	0.21	0.11	0.52	0.14	0.18
C	0.10	0.08	0.10	0.63	0.11
D	005	0.08	0.14	0.09	0.47

In order to achieve higher similarity between data and improve our results, we apply noisy data detection algorithm in the test phase described in Section 3.5.2. The results are shown in Table 10 and Figure 7; the results become better than those shown in Figure 6. For example, grade S accounts for about 55%, and both grade C and D are removed in Cluster 1; grade A about 59% and grade D was removed in Cluster 2; grade B about 64% and grade D are removed in Cluster 3; grade C also about 64%, but grade S and B are removed in Cluster 4; grade D about 50%, and both grade S and C are removed in Cluster 5. We also show the results from lesson 8 to 15 in Figure 8, by applying the same method.

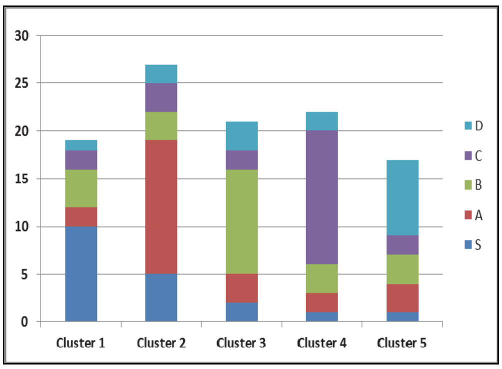

Figure 6: Students' grade prediction based on their comment data for lesson 7.

Table 10: The results in test phase after removing noisy data.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
S	0.55	0.23	0.07	0	0
A	0.18	0.59	0.15	0.18	0.2
B	0.27	0.09	0.64	0	0.3
C	0	0.09	0.07	0.64	0
D	0	0	0.07	0.18	0.50

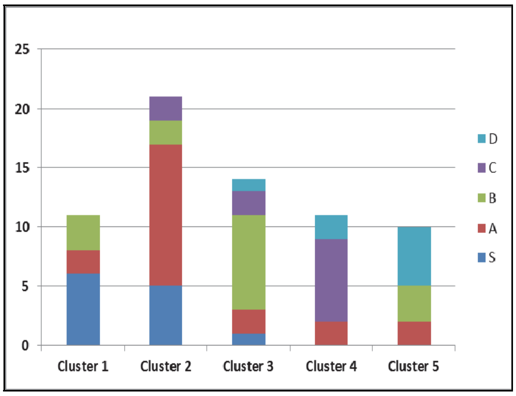

Figure 7: Student grade prediction for lesson 7 after removing noisy data.

Next, we calculated average prediction accuracy of students' grade from lesson 7 to 15 before and after detecting noisy data. The results are shown in Table 11 and Figure 9. The prediction accuracy results are between (59.3%) and (71.0%) for all data, and (63.5%) to (74.0%) after detecting noisy data. The highest accuracy results from the top were obtained in lessons 7 and 12, and the lowest ones from the bottom in lesson 8 and 14.

Table 11: The prediction accuracy results.

Lesson	All data	Noisy data Detection
7	71.0%	74.0%
8	59.3%	63.5%
9	70.0%	73.0%
10	67.3%	69.0%
11	65.5%	68.0%
12	71.0%	73.8%
13	68.3%	70%
14	64.0%	67.0%
15	64.5%	68.2%

This indicates that students wrote good comments in lesson 7. We think they had high motivation to write and express their attitudes to the lesson probably because they took the first lesson on programming at that time. The motivation might probably have become lower in lesson 8 due to difficulty of programming, but rose in lesson 9. In addition, the lessons 11, 14, and 15 have lower results. Finally, the last lesson became better than before. We believe from these views that we have to evaluate comments after each lesson to give feedback to students, and encourage them to write good comments. We believe that using these comments with useful way would improve students' performance.

5 CONCLUSIONS AND FUTURE WORK

In this paper, we discussed the prediction method of students' grade based on C comments data from (Goda and Mine, 2011). The C comments present students' attitudes, understanding and difficulties concerning to each lesson. We applied LSA technique to the comments for obtaining approximate estimations of the contextual usage substitutability of words in larger text segments, and the kinds of meaning similarities among words and text segments. Then we classified the results into 5 groups by using K-means clustering method. To validate our proposed method, we conducted experiments to estimate students' academic performance based on their freestyle comments. The experimental results illustrate the validity of the proposed method.

This study expressed the correlation between self-evaluation descriptive sentence written by students and their academic performance by predicting their grade. In near future, we will develop another method to predict students' grades to get higher accuracy in prediction results. For this step, it is indispensable to devise a method for collecting good comments data that describe educational situations appropriately for each student, and for increasing the quality of the comments.

Collecting comments, however, is not an easy task for a teacher. We have to lead students so that they good describe comments. For example, we should prepare a comment form including items that we would like students to describe. One of the examples are PCNO we used. At this time, giving students' actual examples to write comments based on the objectives for each lesson is also a good option. In addition, we have to motivate students to describe their comments so that they wise up the worth-describing their comments; for example, let them improve their confidence and satisfaction to the lessons by looking back on their comments. Giving automated feedback will also help students

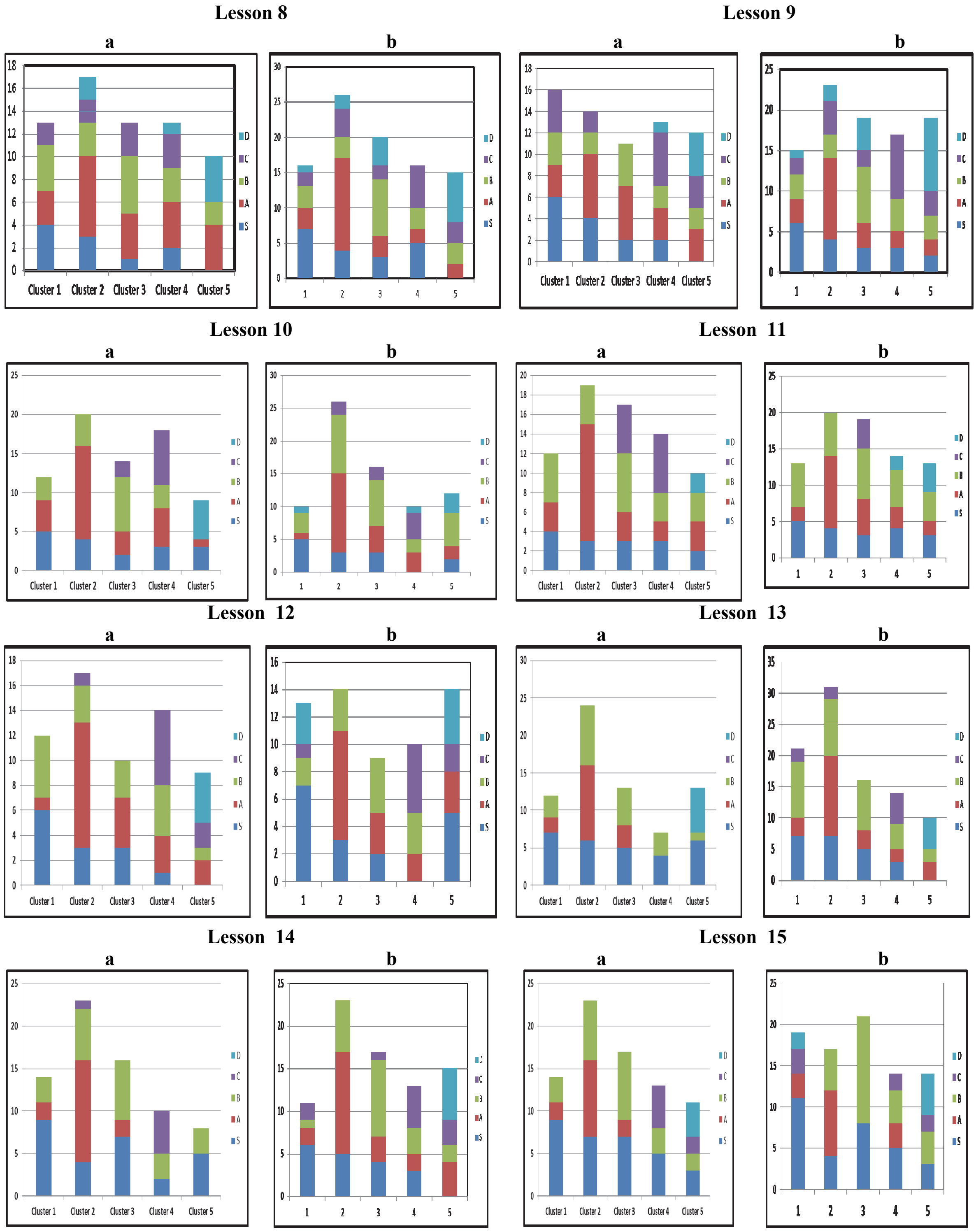

Figure 8: Analysing Comments Data from Lesson 8 to 15, (a) Training Data Results (B) Student's Grade Prediction.

increase their ability of descriptions. At this time, it is preferable that they can share their comments together in writing process.

Finally, further research is necessary to realize environments suitable for activating students' motivation and collect good comments.

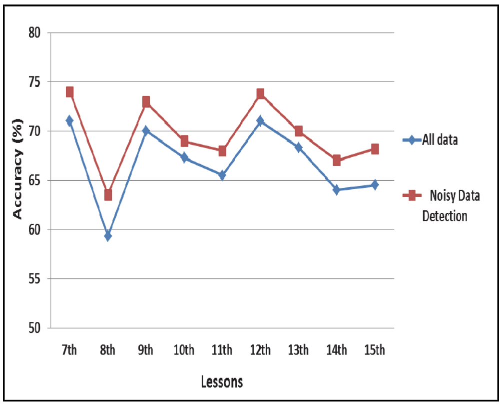

Figure 9: Average prediction accuracy of students' grades from lesson 7 to 15.

We believe this will help a teacher give advice to students and improve their performance. In addition, it leads to an important step for improving performance of comment analysis and their learning status prediction.

ACKNOWLEDGEMENTS

This work was supported in part by *Project for Fostering Value-Creation Advanced ICT Frontier Human Resources by Fused Industry-University Cooperation* conducted by QITO, Kyushu University under the MEXT, Japan, and JSPS KAKENHI Grant Number 24500176 and 25350311.

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Evaluation of Concept Importance in Concept Maps Mined from Lecture Notes

Computer Vs Human

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Keywords: Concept Map Mining, Concept Importance, Lecture Notes, Evaluation Methodology.

Abstract: Concept maps are commonly used tools for organising and representing knowledge in order to assist meaningful learning. Although the process of constructing concept maps improves learners' cognitive structures, novice students typically need substantial assistance from experts. Alternatively, expert-constructed maps may be given to students, which increase the workload of academics. To overcome this issue, automated concept map extraction has been introduced. One of the key limitations is the lack of an evaluation framework to measure the quality of machine-extracted concept maps. At present, researchers in this area utilise human experts' judgement or expert-constructed maps as the gold standard to measure the *relevancy* of extracted knowledge components. However, in the educational context, particularly in course materials, the majority of knowledge presented is relevant to the learner, resulting in a large amount of information that has to be organised. Therefore, this paper introduces a machine-based approach which studies the *relative importance* of knowledge components and organises them hierarchically. We compare machine-extracted maps with human judgment, based on expert knowledge and perception. This paper describes three ranking models to organise domain concepts. The results show that the auto-generated map positively correlates with human judgment (r_s~1) for well-structured courses with rich grammar (*well-fitted* contents).

1 INTRODUCTION

Concept mapping is recognised as a valuable educational visualisation technique, which assists students in organising, sharing and representing knowledge. Concept maps model knowledge so that it can be expressed externally using set of concepts and propositions (Novak and Gowin, 1984). These concepts are organised in a hierarchy with the most general concept at the top and the most specific concepts arranged below (Coffey et al., 2003). Based on the Assimilation theory (Ausubel et al., 1978), this externally expressible concept map is utilised to improve human learning, by integrating newly learned concepts and propositions into existing cognitive structures. Concept maps have been widely used in the educational context, particularly in identifying misconceptions and knowledge gaps, conceptual changes and being utilised as "advance organisers" (Novak and Gowin, 1984), and externalising mental models (Chang, 2007).

However, '*construct-by-self*', where students are responsible for creating their own concept maps, introduces a substantial difficulty for novice students to correctly identify concepts, relations and hence, requires continuous assistance from academic staff. A common alternative is to provide students with maps constructed by human experts (*expert maps)*, placing additional load and intellectual commitment on academic staff.

Although constructing a concept map for a lecture is a one-off process, it needs to be updated continuously, to cope with the changing nature of knowledge. However, due to the lack of human awareness of knowledge representations and a general preference for writing informal sentences over creating network models, concept maps are not yet widely used for learning.

Therefore, recent efforts in this area work toward semi- or fully automated approaches to extract concept maps from text (called *concept map mining*), with the aim of providing useful educational tools with minimal human intervention

(Olney et al., 2012); (Alves et al., 2002); (Chen et al., 2008). However, a significant problem in concept map extraction is the lack of an evaluation framework to measure the quality of machine-extracted concept maps (Villalon and Calvo, 2008). At present researchers rely upon human efforts to evaluate machine-extracted concept maps either through manual judgement or comparison with expert maps.

The majority of works in this area focus on the performance of automated tools using the popular metrics - *precision* and *recall*. These forms of measurement evaluate whether the machine extracted concepts and relations are *relevant*. However, in the educational context, particularly in course materials, the majority of knowledge presented is relevant to the learner, resulting in large part of lectures or textbooks being retrieved and identified for knowledge organisation (Atapattu et al., 2012). But, according to the definition of concept maps, a concept map should be an overview, which organises most important knowledge according to learning objectives (Novak and Gowin, 1984). Hence, the aim of this paper is to discuss a machine-based evaluation technique which studies the *relative importance* of knowledge, focusing beyond the simple measure of *relevancy*.

Current instructional methods widely support verbal learning through linear and sequential learning materials. The literature provides inadequate research to assist transforming linearity of resources into network models such as semantic networks and concept maps. Our approach takes the work that has already been invested in producing legible slides and focus on extracting useful knowledge that are beneficial for both the teacher and the learner. This will be an increasingly important research topic in the decade of Massive Open Online Courses (MOOCs). This paper provides a concise overview of our concept map extraction approach using Natural Language Processing (NLP) algorithms.

In this paper, we hypothesize that the natural presentation layout, linguistic or structural features might influence the human expert's judgement of relative concept importance. We developed three ranking models: 1) Baseline methods which use the natural layout of lecture slides (e.g. titles are the most important, sub-points are the least important); 2) Linguistic features such as grammatical structure of English text; and 3) Structural features such as proximity, number of incoming and outgoing connections, and degree of co-occurrence. We compare each of these models with human judgement using Spearman's ranking correlation coefficient (r_s). According to the results (Section 5), outcome of the structural feature model positively correlates with human judgment. There is a strong correlation ($r_s > 0.7$) for well summarised courses with rich grammar (i.e. *well-fitted* content). The correlation ranges from *well-fitted* to *ill-fitted* proportionally with respect to the quality and structure of the content. Lecture notes with some potential issues, including excessive information, category headings (e.g. key points, chapter 1), confusing visual idioms and ambiguous sentences (i.e. *ill-fitted* content) result in poor machine interpretation and hence, poor correlation with human judgement.

The concept map extraction, particularly from course materials, is beneficial for both students and educators. It organises and represents knowledge scattered throughout multiple topics. These maps can be used as an assessment tool (Villalon and Calvo 2008, Gouli et al., 2004) to identify understanding about concepts and relations. Additionally, these concept maps can be used as an "*intelligent suggester*" to recommend concepts, propositions, and existing concept maps from the web (Leake et al., 2004). In the educational context, these maps can provide scaffolding aid for students to construct their own concept maps. Students learn better when they are encouraged to fill in blank links (relations) rather than blank nodes (concepts) (Maass and Pavlik, 2013). Concept mapping has also been utilised widely in question generation (Olney et al., 2012) and question answering (Dali et al., 2009). The preliminary concept maps extracted from this research can also be extended as an ontology for domain modelling in intelligent systems (Starr and Oliveira, 2013).

This paper includes a background study of various concept map mining evaluation techniques in Section 2. In Section 3 and 4, we discuss about our core research of concept map mining from lecture notes and ranking model respectively. We evaluate our approach with human experts and present results and analysis in Section 5 and our study is concluded in Section 6.

2 RELATED WORK

The evaluation of the quality of machine-extracted knowledge representations is a challenging and tedious task. This can categorised into three dimensions as structural, semantic and comparative evaluation (Zouaq and Nkabou, 2009). In the concept mapping perspective, assigning scores to extracted elements such as concepts and relations can be classified as structural evaluation. In a traditional scoring system, 1 point is assigned for a valid proposition, 5 points for each level of adopted hierarchies, and 10 points for cross-links (Novak and and Gowin, 1984). Although, the scoring technique provides information about creator's knowledge structure, this technique is time-consuming when assessing large-scale maps (Coffey et al., 2003).

In semantic evaluations, human experts are involved in judging the validity of machine-extracted maps. These types of studies are affected by the subjective judgment of human experts. Therefore, an average agreement among participants (*inter-rater agreement*) is compared with *human-to-machine agreement*. Generally, machine extractions are acceptable when *human-to-machine agreement* is equal or higher than *inter-rater agreement* (Hearst, 2000). Other research utilises expert-constructed maps as a gold standard to compare with machine-extracted maps (Villalon and Calvo, 2008). It is uncertain of the objective behind generating concept maps from computer algorithms in the presence of already constructed expert maps.

In comparative analysis, the machine-extracted concept maps are compared with other tools, which are built for the same purpose and test using the same corpus. TEXT-TO-ONTO is a popular ontology extraction tool. It is compared with TEXCOMON (Text-Concept map-Ontology) that automatically extracts concept maps from text (Zouaq and Nkabou, 2009). In order to use the comparative evaluation, other tools should exist which are built for same purpose. We demonstrate our approach using Microsoft PowerPoint Framework (as a commonly used lecture note format), although our approach is not constrained to PowerPoint but generalises across any common lecture note formats such as OpenOffice, Latex, and Apple Key note with a structured template for headers and text. To the best of our knowledge, there are no existing tools which do this.

However, despite the benefits to the educational context, state of art studies focused on *concept existence*, and not their *relative importance*. Our work adapts several structural features (e.g. proximity, incoming and outgoing links) (Leake et al., 2004) and graph-based metrics (e.g. degree) (Zouaq et al., 2012) to rank the concepts according to their importance. However, we also use linguistic features, semantic information and the association between terms to mimic the human judgment using machine algorithms. This resolves syntactically and semantically incomplete information in lecture notes which recognised as a key challenge in applying computer algorithms to semi-structured lecture notes.

3 CONCEPT MAP EXTRACTION

Our core research focus is on extracting useful knowledge as concept maps (*concept map mining*) from educational materials, particularly from lecture notes. Current concept map mining techniques rely upon informational retrieval techniques (e.g. vector space model, C-value/ NC-value), linguistic-based approaches (e.g. part-of-speech tagging, language models) or hybrid models (Frantzi et al., 2000). Information retrieval approaches suffer from probable semantic loss. Although linguistic-based techniques address this issue and extract nouns as semantic concepts, nouns may be present that are not semantic concepts in that particular domain. In order to overcome these issues, studies based on linguistic techniques utilise external dictionaries and thesaurus. However, these types of external resources are very limited for specific domains such as Computer Science.

Therefore, our work utilises NLP algorithms to extract concepts, relations using syntactic parsing and part-of-speech tagging. We rank extracted concepts using statistical features such as term frequency, degree of co-occurrence, proximity (see Figure 1).

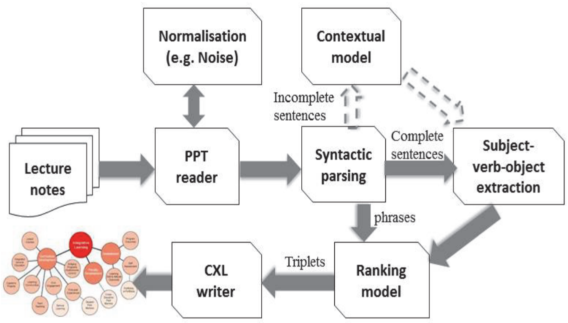

Figure 1: Overview of concept map extraction process.

As shown in Figure 1, our system relies on the use of the lecture notes presented as set of slides. Therefore, it is capable of extracting rich text features such as underline, font color and highlights and type of text such as a title, bullet point, and sub-point. Lecture notes frequently contain noisy data such as course announcements and assignment details that are irrelevant for a knowledge representation. The system detects and resolves them automatically by utilising *co-occurrence* between domain-related and unrelated topics. For example, if course title is co-occurred with some terms in body text, that pair of terms has strong relation with the domain, and hence recognised as a domain-specific terms.

Lecture slides occasionally contain incomplete and ambiguous English sentences for machine interpretation. Therefore, it is challenging to apply NLP algorithms to extract knowledge from lecture slides. We implemented a contextual model which automatically replaces syntactically and semantically missing entities (e.g. subjects or objects of sentences). Our initial research also focused on resolving pronouns (e.g. *it, their*) and demonstrative determiners (e.g. *these, this*) using a backward search approach (under review).

In contrast to other related works in literature (Chen et al., 2008), which has no relation labels among extracted concepts, our work generates concept-relation-concept triplets by analysing subject-verb-object (SVO) in English sentences. We utilise the link grammar parser developed by CMU[1] to extract SVO in English sentences and applied the greedy approach to the remaining text to identify key terms using part-of-speech tags. The extracted key terms are ranked using the approach discussed in Section 4.

The extracted concepts and relationships are arranged according to their importance, which produces a CXL (Concept map extensible language) file which can be directly exported to IHMC cmap tools[2] [1]for visualisation (Figure 2).

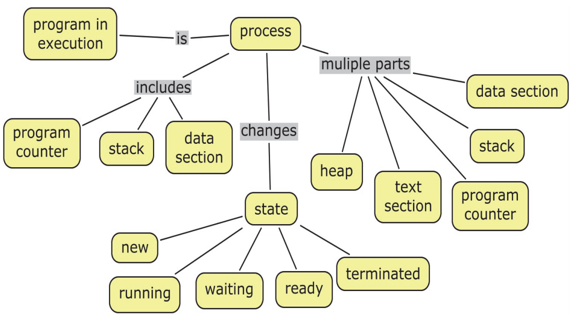

Figure 2: An example of an extracted concept map from 'process' topic of Operating system course.

4 RANKING MODEL

In order to construct a high quality concept map, both domain knowledge and hierarchy are equally significant (Novak and Canas, 2006). This section discusses three candidate models which arrange concepts by their importance.

4.1 Baseline Model

Our knowledge source (i.e. lecture slides) contains a natural layout of presentation title, slide headings, bullet points, and enumerated sub-points. Therefore, one can argue that this layout can directly transfer to a hierarchy. To validate this assumption, we implemented a baseline model by integrating 'text location' in lecture slides (Table 1).

Hypothesis I: *Text location allocated by the natural layout of presentation slides might influence human judgment of which concepts are most important*

Table 1: concept importance by location.

Location	Rank
Title	3
Bullet statement	2
Sub-point	1

However, a concept can occur in multiple locations. In order to select the most suitable location for such concepts, we implemented a "link-distance algorithm" which can be found in our previous work (Atapattu et al, 2012).

4.2 Linguistic Feature Model

First, we used the greedy approach to extract nouns and noun phrases using part-of-speech tags (Atapattu et al., 2012). Although, this approach is efficient for extracting isolated nouns or noun phrases, we found it difficult to extract phrases joined by prepositions (e.g. *of, for,in*) and conjunctions (e.g. *and, or).*Therefore, we developed a new approach using the link grammar parser of CMU[2], which produces syntactic parse trees (Figure 3).

It is straightforward to extract nouns (*leaf* nodes) or noun phrases (*pre-terminal* which is one level above *leaf*). This approach outperforms the first method and hence, solves the preposition and conjunction issue.

Our hypothesis is based on the recommendation of using the smallest number of words for a concept (Novak and Canas, 2006).

[1] http://cmap.ihmc.us/

[2] http://www.link.cs.cmu.edu/link/

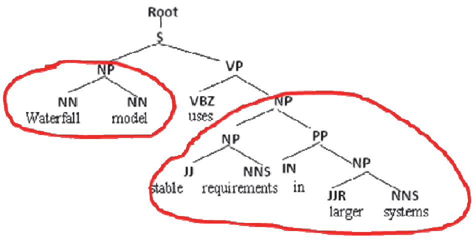

Figure 3: Syntactic parser tree of an example English Sentence.

Hypothesis II: *Simple grammatical structures (nouns, noun phrases) of Lecture slides might have higher influence than complex grammatical structures (nested sentences, dependent clauses, indirect objects) for human judgment of which concepts are most important*

Table 2 shows our ranking based on grammatical structure.

Table 2: Concept importance by grammatical structure; NP: noun phrase, PP: prepositional phrase, S: sentence, VP: verb phrase (see all tags in http://bulba. sdsu.edu/jeanette/thesis/PennTags.html).

Feature	Example grammatical structure	Rank
Noun phrase	(NP (NP (NNP **Advantage**)) (PP (IN **of**) (NP (NN **unit**) (NN **testing**))))	3
Simple sentence	(S (NP (NNP **Process**)) (VP (VBZ **is**) (NP (NP (NN **program**)) (PP (IN **in**) (NP (NN **execution**))))))	2
Complex sentence	(S (NP (DT A) (NN **software**) (NN **process**)) (VP (VBZ **is**) (NP (NP (DT **a**) (NN **set**)) (PP (IN **of**) (NP (NP (ADJP (RB **partially**) (VBN **ordered**)) (NNS **activities**)) (CC **and**) (NP (NP (JJ **associated**) (NNS **results**)) (SBAR (WHNP (WDT **that**)) (S (VP (VBP **produce**) (CC **or**) (VBP **maintain**) (NP (DT **a**) (NN **software**) (NN **product**))))))))))))	1

As shown in Table 2, complex sentences contain nested sentences (S), clauses (SBAR) and conjunctions (CC). Therefore, we assume these sentences contain definitions or elaborations rather than the abstract concepts of a knowledge representation. Verb phrase (VP) is the remaining grammatical structure which is usually nested with a verb (or multiple verbs) and a noun phrase. We usually extract NPs from verb phrases.

4.3 Structural Feature Model

In the third candidate model, we integrate some structural features (e.g. incoming, outgoing links and proximity) which have already been proposed in Zouaq et al., 2012 and Leake et al., 2004 and new distributional features (e.g. typography and co-occurrence) that are unique to presentation framework.

Hypothesis III: *Structural (Incoming and outgoing links, proximity) and distributional (term frequency, degree of co-occurrence, typography) features might influence the human judgment of which concepts are most important*

Log Frequency Weight

The system counts the occurrence of *nouns* or *noun phrases* and normalises the term frequency (t_f) (Atapattu et al., 2012). This value is significant than typical term frequency measure used in information retrieval applications since our 'terms' are restricted to nouns or noun phrases.

$$W_t = log\,(1+ t_f) \qquad (1)$$

Incoming and Outgoing Links (I/O links)

We keep track of the number of incoming (n_i) and outgoing (n_o) connections for each node. The 'root' node contains only outgoing links and leaf nodes contain only incoming links. Those that have more outgoing than incoming are identifies as of greater importance.

These metrics are significant to demonstrate disjoint nodes from central concept map. Our system provides this information as a conceptual feedback for teachers. This feedback can be used to reflect on whether their expert structures have been transferred successfully to teaching material. If not, students struggle to organise disjoint information into their knowledge structures since there is no relation between new and existing information (paper under submission).

$$W_o = n_o \qquad (2)$$

$$W_i = n_i \qquad (3)$$

Degree of Co-occurrence

Our hypothesis is '*if two key terms co-occur in many slides (equals to pages in other documents), it is assumed that those two terms have a strong relation*' and hence, can be chosen as domain concepts. To measure the degree of co-occurrence, we use the Jaccard coefficient, a statistical measure which compares the similarity of two sample sets.

In order to measure the degree of co-occurrence between term t_1 and term t_2, first calculate the number of slides, that t_1 and t_2 co-occurs. This is denoted as $| n_1 \cap n_2 |$. Then calculate the number of slides the term t_1 ($|n_1|$), t_2 ($|n_2|$) occurs. The degree of co-occurrence of t_1 and t_2 is denoted by J (t_1, t_2) is,

$$J(t_1, t_2) = \frac{|n_1 \cap n_2|}{|n_1 \cup n_2|} = \frac{|n_1 \cap n_2|}{(|n_1| + |n_2| - |n_1 \cap n_2|)} \tag{4}$$

This value is utilised as a key decisive factor for noise detection since key terms such as a*nnouncements, assignments* have low degree of co-occurrence with other domain concepts.

Typography

Lecture slides often contain emphasised texts (e.g. different font color, underline) to illustrate their importance in the given domain. We introduced a probability model to select candidate concepts using their level of emphasis. According to the proposed model, terms which contain infrequent styles are allocated higher weights. More information of this work can be found in Atapattu et al., 2012.

Proximity

We consider the 'lecture topic' as the *root* (or central concept) of concept map. Therefore, we hypothesise the concepts that have a higher proximity to the *root* are expected to be more important than those with lower proximity (Leake et al., 2004). We denote the proximity weight (*Wp)* by calculating the number of nodes (d_n) from root to participating node (inclusive).

$$W_p = \frac{1}{d_n} \tag{5}$$

Generally, a concept map with 15 to 25 nodes is sufficient to assist learning while not providing an overwhelming amount of information (Novak and Canas, 2006). Thus, the aim of introducing a ranking model is to construct a conceptual overview with the most important domain knowledge from the lecture notes.

5 EVALUATION OF CONCEPT IMPORTANCE

We conducted experiments with domain experts (lecturers) to study their judgment of concept importance in their lecture notes. These data are then compared with the machine predictions to assess the accuracy of the auto-generated concept maps.

Data

Seven computer science courses across different Undergraduate levels (1st year, 2nd year, 3rd year and 4th year) were selected. These courses contain a combination of content types such as text, program codes, mathematical notations, tables and images. The seven courses chosen were *Introductory programming (IP), Algorithm design and data structures (ADDS), Object oriented programming (OOP) (level 1); Software Engineering (SE) (level 2); Distributed systems (DS), Operating systems (OS) (level 3); and Software Architecture (SA) (level 4).* Each participant was provided with approximately 54 slides including one to three topics. Tasks were designed to be completed within 30 to 45 minutes, with the variation due to how recently the lecturer had been teaching the course.

Seven lecturers from the Computer Science School volunteered to assist with the experiments. They are the domain experts of selected topics who have extensive experience in teaching the courses.

Procedure

This study required participants to rate the domain concepts according to their importance. The judgment was expected to reflect personal opinions based on their knowledge and perception. However, we provided a few tips, such as how the importance of a concept can be affected by the learning outcome, course objective, and examination perspective. These instructions did not have any relation with the factors we considered in developing our concept map extraction tool.

We provided colour pens and printed lecture slides to the participants who preferred working in a paper-based environment. The rest used their computers or tablets to highlight the domain concepts. The three rating scale given to the participants consisted of '*most important', 'important',* and *'least important'* using three colours *'red', 'yellow' and 'green'* respectively. Participants tended to rate single concepts as well as noun phrases.

During the experiments, we did not show the machine-extracted concept maps to the participants. They only had access to the course lecture slides. This could prevent any influence arising from structure or layout of concept maps for the human judgement.

Results

We developed a simple program to extract the annotations of participants. A Java API for

Microsoft framework[3] was used to extract highlighted texts. Using this approach, we extracted 678 concepts from 376 lecture slides. The average number of concepts per slide was approximately 2.2 except in IP course. In IP, multiple slides repeated the same content in animations. Therefore, in IP, the average number of concepts per slide is 0.8.

The highlighted texts are categorised and sorted based on their ranks from 3 to 1 (most important to least important). Similarly, our system arranged important concepts according to ranks assigned by each candidate models.

In the baseline model, our ranking algorithm allocated rank 3 for text located in *titles* (see Table 1) and 0 for concepts annotated by human, but not retrieved by machine. The two rankings were compared using ranking correlation coefficient and results are presented in table 4. The correlation (r_s) is close to 0 for the majority of the courses except for ADDS and SA. This implies there is no linear correlation between human judgment of concept importance and the natural layout of presentation software. This causes us to question and reject the original hypothesis that assumes most important, important and least important concepts are located in titles, bullet points and sub points respectively. Therefore, the approach which utilises the natural layout of lecture slides for knowledge organisation does not produce an acceptable outcome (Ono et al., 2011). Further, topic map extraction in Gantayat et al., 2011 and Kinchin, 2006 should focus on fine-grained course contents in addition to lecture headings. The feedback obtained from lecturers regarding concept importance is significant for students. This implies layout of slides is not overlapping with lecturer's judgment of what is more important in the lecture.

However, if we could expand the ranking to a few other levels, we could expect a slightly more positive correlation from the baseline model. This occurs because the ranking model categorises remaining concepts as false positive (rank=0) that have not been ranked by human and false negative (rank =0) that have not been retrieved by machine, but annotated by human.

The linguistic feature model assumes the grammatical structure of text (noun / phrases, simple sentences and complex sentences) has an impact for selecting candidate concepts. Similar to the baseline model, this has assigned higher rank (rank = 3) for noun or noun phrases and lower rank (rank = 1) for complex grammatical structures (see Table 2). However, Table 4 shows the correlation is closer to 0 for all the selected courses. This reveals that, in addition to single terms and brief phrases, simple and complex sentences contain candidate domain concepts. Therefore, a deep analysis of all text contents irrespective of their grammatical complexity is significant to extract the useful knowledge from lecture slides.

In the structural candidate model, we normalise weights of each metrics within the range of 0-1. The influence of each metric (discussed in Section 4.3) is determined by the parameter values (Table 3). For example, terms with higher outgoing links can be more general, thus more important than terms with higher incoming links. We trained our weighting function using previously annotated data for a previous study (Atapattu et al., 2012). The training data contains slides extracted from recommended text books, university course materials and randomly chosen topics from web.

Table 3: Best fit parameter values for Structural features.

Feature	Best fit parameter values
Outgoing links	0.923
Proximity	0.853
Typography	0.764
Co-occurrence	0.559
Frequency	0.514
Incoming links	0.281

After obtaining best fit parameter values, we calculated the aggregate weight for each term in the study and sort them in the descending order of weights. Our system defines *upper*, *medium* and *lower* threshold values in order to rank the *most important* (above upper), *important* (in-between upper and medium) and *least important* (in-between medium and lower) domain concepts. These three threshold values vary depending on the number of concepts retrieved. Finally, similar to other two candidate models, we compare the ranks given by participants with machine predication. The results can be found in the last column of Table 4.

The results are interpreted as strong positive or strong negative if r_s close to +1 or -1 respectively. There is no linear correlation when r_s is close to 0 and hence, consider as independent variables.

Since the selected courses contain combinations of content (e.g. text, images, program codes), we claim our data ranges from *well-fitted* (e.g. SE and SA) to *ill-fitted* (e.g. IP and ADDS) contents for 'machine interpretation'.

[3] http:/poi.apache.org/

Table 4: Spearman's ranking correlation (r_s) between candidate models and Computer Science courses.

Model	Baseline (r_s)	Linguistic (r_s)	Structural (r_s)
SE	0.193	0.247	0.805
ADDS	0.436	0.252	0.435
IP	0.113	0.293	0.353
OS	0.325	0.240	0.715
DS	0.183	0.129	0.455
OOP	0.287	0.347	0.521
SA	0.605	0.050	0.806

$$r_s = \frac{1 - 6\sum d_i^2}{n(n^2 - 1)} \tag{6}$$

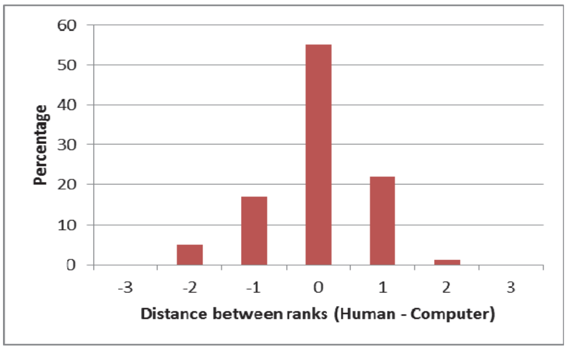

Figure 4: Distance between human and computer ranking against number of concepts (%) in Software testing topic (r_s=0.813).

In the structural feature model, our results show satisfactory correlation for the majority of the courses and strong positive correlation for SE, SA and OS courses. As an example, in Software Testing topic (Figure 4), 55% of concepts (out of 64) overlap between computer and human (distance = 0) and 39% of concepts indicate one level difference between ranks. This implies 94% of concepts extracted from machine algorithms are closely aligned with human judgement, resulting in a machine extraction of approximate expert maps. Both OS and SE lecture slides are constructed using popular text books written by Sommerville and Silberschatz respectively and SA lecture slides were well written and structured. Therefore, those topics contain rich grammar, good summarisation and emphasise domain concepts. These *well-fitted* contents assist relatively straightforward machine interpretation.

Conversely, the remaining course topics include combinations of category headings (e.g. review, summary, welcome, and today's format), additional text boxes with excessive content, ambiguous texts that are difficult to resolve and repetitive contents in consecutive slides for animations (i.e *ill-fitted* content). These types of content reduce the reliability of machine extraction algorithms. Hence, as a general rule, machine-extracted concept map has a significant correlation with human judgment in *well-fitted* contents.

This study highlights the importance of structural features rather than natural layout or grammatical structures. This implies that important information in the lecture should be emphasised, and recapped. Lecturer should also construct probable links with the central idea of the topic. This ensures that approximately reliable machine extraction of concept maps from algorithms developed in this work.

In this study, we only had a single expert participating for the assessment of each course. Therefore, we cannot measure the *inter-rater agreement* since the author of the material is the only person having an expert knowledge structure of the content.

We received evocative feedback from domain experts during the experiments.

"*I tend to think that summary generally contains things that have already been discussed. But, I found a new concept in the summary which hasn't seen in the lecture note. I read the lecture from the beginning again to locate that concept, but couldn't find it*".

This comment provides an evident that there can be disjoint concepts included in lecture note which are not fitting with students' knowledge structures.

"There are tables which provide comparison between important concepts. How does this handles by the system?"

This is one of our challenges. The data comes from tabular form include useful domain concepts. However, we have not yet implemented a feature to tackle the comparisons in tabular data.

"*Examples are very useful to learn concepts, but they are not concepts. Therefore, I am not sure whether they should be included or not. I have included them in cases where I think they are very useful*".

"In IP, many domain concepts are introduced via analogy. So, are they also be classified?"

We do not have an exact answer for this comment. Examples or analogies can be included into the extracted concept map, if they are strongly correlates with domain or emphasised within the context.

In our future work, we plan to extend the experiments across disciplines to create a general model. The focus of this study is limited to measure the quality of 'concept' ranking according to their importance. We plan to extend our study to measure the quality of extracted 'relations'. It is difficult for participants to judge relationships from lecture slides since relations are not highly visible like concepts. Therefore, we plan to provide extracted concept maps using IHMC cmap tools to collect feedback on the 'strength of extracted relationships'. Lecturers will also receive conceptual feedback regarding deficiencies in knowledge organisation of their courses. This includes disjoint concepts without any relation to the central concept map and relations without proper labelling. This process should improve the legibility of the materials.

6 CONCLUSIONS

The primary challenge of concept map mining is the lack of a suitable evaluation framework. The existing approaches utilise human experts' judgement or expert maps as the gold standard to measure the quality and validity of machine-extracted maps. However, these studies focus on *concept existence* using IR metrics – *precision* and *recall*, and not the concept ranking according to their importance. Therefore, this paper proposes a machine-based evaluation mechanism to assess mined concept maps in an educational context. We compared the machine-generated maps with human judgment and obtained strong positive correlation (r_s ~1) for *well-fitted* courses.

This work has potential to be utilised as conceptual feedback for lecturers to have an overview of knowledge organisation of their courses. Machine-extracted concept maps require the assistance of domain experts to validate. However, this effort is substantially smaller than that required to construct a concept map manually. In future work, we plan to provide task-adapted concept maps instead of hints in intelligent tutoring environment. This will help students to identify knowledge gaps and to improve their organisation of knowledge. We believe that this will help to improve the depth of meaning that students can extract from their learning.

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Using iTextbook as an Alternate Frontend to Learning Management Systems

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Keywords: Learning Management Systems, e-Books, Interactive, iTextbook, iBooks, Mobile Learning.

Abstract: Learning management systems (LMS) have been a popular tool for delivery of learning content as well as the management of learners and courses. In recent years, the ubiquity of mobile devices such as smartphones and tablets has seen the increased popularity of using them to consume eBooks. While the LMS is popular among administrators, accessing content on mobile devices appear to be the preference of our learners. Furthermore, there are reports on a number of shortcomings with learners using the LMS, e.g., the experience of using LMS*es* on mobile devices falling short and learners are less engaged interacting with the LMS than with their mobile devices, etc. In this paper, we investigate the idea of using eBooks as an alternative frontend for learners to interact with the LMS. A proof of concept eBook was developed for a data management course to showcase how content on the LMS can be deployed via the eBook interface while connecting our learners to the LMS for learning management. We find that this approach delivers a rich and immersive experience to our learners, as they would expect from their devices. The outcomes also gave us food for thought regarding how LMS*es* may evolve in the future.

1 INTRODUCTION

Learning Management Systems (LMS) such as Moodle, Sakai, Dokeos, Desire2Learn and WebCT are popular vehicles for delivery of e-Learning. While each specific product differ, a LMS is characterised by its Web-based delivery of learning content and the added provision of learning related tools for stakeholders (Sessink et al., 2003; Ozdogru and Cagiltay, 2007; Lehsten et al., 2010), e.g., live chats, discussion forums, online assessments, course management, etc. The LMS is popular because of features important to the course administrators. Among them (Phankokkruad and Woraratpanya, 2009; Hashim and Ahmad, 2011) includes the ability to customise the system according to an institutes' business rules and reporting needs; and the ability to manage individual student learning.

Recently, the proliferation of Internet-connected mobile devices have seen eBooks making in-roads. These devices can operate as readers while offering more features than a traditional printed book. This includes a new level of reading experience, convenience via a quick and easy distribution method (Binas et al., 2012), interactivity, multimedia experience, and connectivity between the reader and the publisher. Furthermore, an eBook can be searched, encourages better and consistent formatting (hence, cognition), and a more integrated experience as content are grouped together as chapters instead of separate files on the LMS. These features make the eBook a desirable learning tool (Oh and Shi, 2012; Yeh, 2010) and so provide benefits that a LMS cannot deliver.

What we are observing is the divergence in the choice of tools among stakeholders. The LMS delivers what course administrators desire but the pedagogical delivery of content on the LMS is not what a learner prefers (Sun et al., 2008). On the other hand, an interactive eBook would appeal to learners because of its convenience and its rich immersive learning experience. However, it lack the ability to manage individual learners that the LMS provides.

Our personal opinion is that these technologies do not have to diverge. Instead a bridge could be built to deliver the best of both worlds. The motivation and the discussion in this paper is thus about how we could deliver such a vision, where the eBook becomes a frontend for learners, and that learning from the eBook continues to allow an instructor to manage their learners using the facilities of a LMS. A proof of concept has been implemented to showcase how this can be achieved. In this paper, we discuss the design considerations undertaken as well as our reflection on the outcomes.

In the next section, we present literature reporting learners' preference for an alternative to a LMS and also recent developments in LMS*es* and learning on mobile devices. Section 3 introduces the iBooks[1] ecosystem and a discussion of the design considerations taken to develop the proof of concept so as to showcase the possibility of an alternate frontend. We then reflect on the outcomes in Section 4 before concluding in Section 5 with a roadmap of our future works.

2 RELATED WORK

The electronic learning (e-learning) popularity has increased in the past ten years due to the factors such as flexibility, afordability and quality of eduation. The new technology sort of using web as teaching tool for individuals. E-learning lets students and instructors participate in learning activities and access a wide range of resources independent of time and place (Li et al., 2008; Li et al., 2009). However, there are problem involved in this technology that consiste of management, resource distribution and personalization.

From our survey, the first mention of LMS inflexibility was reported in (C. and Lee, 2007). According to McLoughlin *et. al.*, the system limits learner interaction by restricting them to the way content could be accessed. The study was followed by Scalter's (Sclater, 2008) report that learners using a LMS are less engaged than those who use mobile devices. As social networking, blogs and other Web 2.0 developments mature, the emergence of mobile learning (m-Learning) was proposed as a way to augment an existing LMS. The intent (Downes, 2006) is to compensate for what the LMS lacked, for example, in areas of collaboration and mobility. As demand for learning on mobile devices increase (Johnson et al., 2010; Casany et al., 2012), the seamless integration between m-Learning and the LMS gains significant priority. The initial development in this direction focused on interoperability standards (Sclater, 2008), where the primary objective was to make the LMS accessible from mobile devices. There are two ways to achieve this: (i) extending the LMS so that m-Learning is fully and intrinsically supported; or (ii) retrofitting the presentation layer so that it is mobile browser compatible.

The former is usually an expensive exercise that often require reworking the LMS and building native apps for each device type. The later which is more commonly adopted[2], allows LMS access from mobile devices but the user experience is often worse off than its desktop version *and* for the LMS used at this university, the mobile access also offers very limited features. In our informal review of common LMS used (i.e., D2L, WebCT, Moodle and Blackboard), we saw a few consistent themes in current state of the art, namely

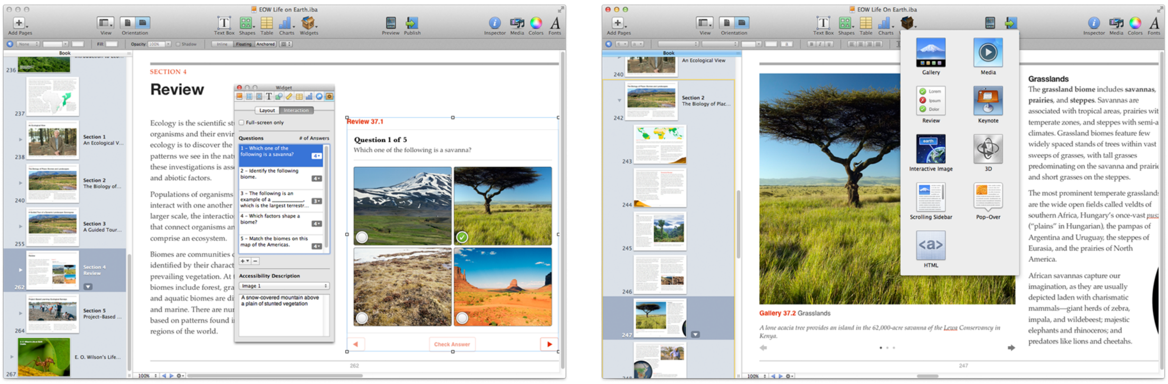
- the LMS running on a mobile device does not exploit hardware features such as location and camera to deliver content;
- access to the LMS is 'stuck' in the classic desktop-oriented client/server model (Rösling et al., 2008; Ssekakubo et al., 2011; Aydin and Tirkes, 2010), where each interaction requires a server response;
- support for file format is limited and so the learner suffers *loss of context* as a result of having to switch from one app to another on their mobile devices;
- and because of the above, the user interaction on mobile devices has a *low fidelity* response because of the "less than fluid" touch interaction that feels more like mouse-click operations.

Despite the new dimension that mobile touch-based devices bring to m-Learning, what we conclude agrees with (Park, 2005; Graf and Kinshuk, 2009; Ramirez-Gonz'lez et al., 2012), i.e., the LMS*es* are not catching up. Instead LMS*es* appear increasingly focus on playing their role fieldworks as an administrators' system. What this means for the learner is that the experience with a LMS will continue to feel *second-class* (Snae and Bruckner, 2008), especially when crucial m-Learning characteristics including portability, immediacy, individuality and accessibility are already lacking. More importantly, m-Learning is already pointing to new possibilities that will further diverge from what current LMS*es* provide. For example, m-Learning affords location-aware content delivery, i.e., a student who is connected to a local wireless network can retrieve a full multimedia video and when the student is on the move, a voice-only discussion of the same content is streamed.

There have been research on how to improve the LMS in various ways. In (Chan and Ford, 2007), the project explored the use of mobile phones to create multimedia content about fieldworks so that they are included as portfolios within the LMS. The portfolios act as digital evidence of knowledge acquired

[1]iBooks is an e-book application by Apple Inc.

[2]The later option is commonly adopted because only the presentation layer of the LMS needs to be changed. Usually, this means (i) detecting the kind of browser one uses and (ii) then attaching a specific CSS in the HTTP response.



(a) (b)

Figure 1: the *iBooks Author* is the content development tool to create *iTextbook*s for the iOS devices. The technology is a mix of EPUB standards and proprietary extensions: (a) the stand out feature of this tool is that it works like a word processor or a simple desktop publishing software; and (b) the use of widgets (which are created using HTML, CSS and JavaScript) gave infinite possibilities to what the interactive eBook can offer.

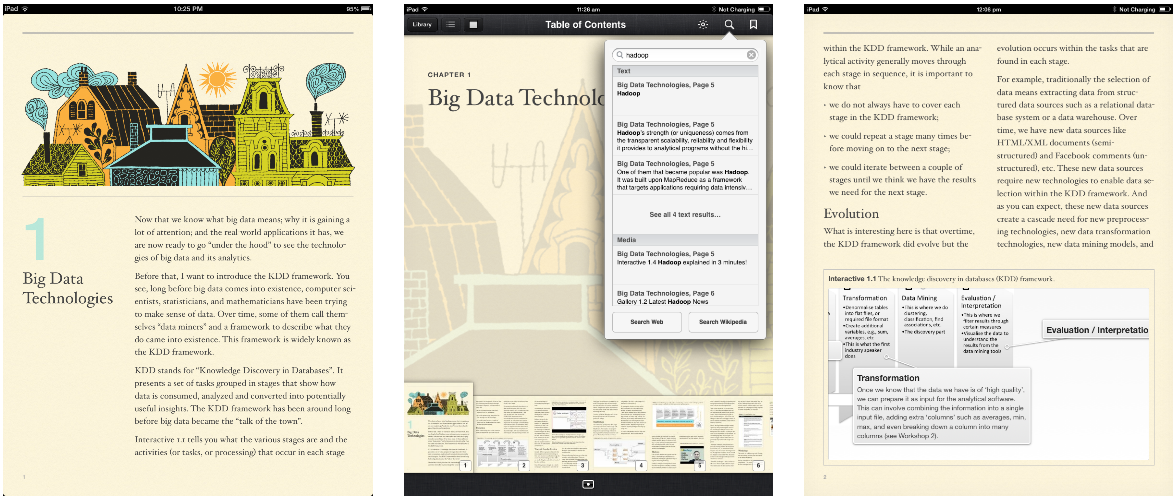
by a learner and the results of the exercise is an exemplar of how m-Learning is taking roots. Subsequently in (Casany et al., 2012), Casany *et. al.* designed a service-oriented architecture around Moodle to expose the LMS services to other apps. This approach comes closest to the deep integration desired between a LMS and m-Learning. Where (Casany et al., 2012) focused on building a LMS for 'sharing', Martin *et. al* (Martin et al., 2010) focused on developing a framework that allows collaborative and social learning apps to be easily built. An app created from the `M2Learn` framework (Martin et al., 2010) has the potential to deliver a rich immersive experience while staying deeply integrated with an LMS (e.g., Moodle). These works went beyond retrofitting a LMS on the mobile device but instead, are examples of attempts to exploit the additional learning benefits afforded by mobile touch devices.

What has happened since is the introduction of *iBooks Author* in 2012 and the increasing "opening up" of LMS*es* as service-oriented architectures. This first version of an advanced eBook authoring platform gave insights into a different way of exploiting mobile touch devices. It was a tool that requires no programming knowledge from the content developer. To create content, developers use a familiar word processing like interface with *widgets* that one can drop to achieve interactivity and other rich immersive experiences. Without the need to code, an easy to use interface and an unlimited set of 'widgets', this approach is highly scalable. And with widgets to enable the connection back to the LMS, this interactive eBook could become an attractive alternate frontend. Hence, our interest for the investigation reported in this paper.

3 USING iTextbook AS THE LMS FRONTEND

As mobile devices become more affordable and powerful, eBooks will become ubiquitous and its technological advances will allow it to be an important facet of m-Learning (Fang et al., 2012; Pesut and Zivkovic, 2011). Currently, the EPUB (see *http://en.wikipedia.org/wiki/EPUB*) format is an open standard developed by the International Digital Publishing Format (IDPF) for publishing of eBooks. The standard defines a number of features, e.g., digital rights management (DRM), the use of tables, images, sound, embedded annotation, book marking, etc., such that the EPUB can be rendered consistently (and properly) across different devices and their specific eco-system. One of the key design aims of the EPUB format is therefore cross-platform portability. Unfortunately, this design aim has also held back on allowing eBooks to maximise device specific strengths. The high-specification iPad and Nexus tablets are good examples and consequently, vendors all opted for proprietary EPUB formats (see *http://en.wikipedia.org/wiki/EPUB*).

The EPUB format is a combination of HTML, CSS and JavaScript technologies. This has allowed specifics to be easily added and in the case of iPad devices, this proprietary EPUB format is known as *iTextbooks*. Essentially, it is an eBook with an extended set of proprietary capabilities (or functionalities). And instead of having to code an 'app' to run on the device, content developers use a tool call the *iBooks Author* as shown in Figure 1. An *iTextbook* is distributed by publishing it on the *iBookstore* – an



(a) (b) (c)

Figure 2: Implementing a proof of concept on a topic taught in a unit by one of our authors: (a) the first page that welcome the learner like any usual book publishing but with a magazine accent to it; (b) the ability to search eliminates the need for indexes but more importantly, users can find what they want quickly with all the content in one place; (c) widgets such as the interactive diagram shown here differentiate an interactive eBook from a traditional textbook or the LMS.

EPUB content sales and delivery system for the iOS eco-system, or it can be downloaded via a Web URL if it is to be distributed free of charge.

To articulate our vision of using *iTextbook* as an alternate frontend, we shall walk the reader through the process of creating our proof of concept[3]. The proof showcases how common LMS functionalities can be implemented on an *iTextbook* (using a variety of built-in and third-party widgets) and how the learning experience is enhanced as a result. Where appropriate, we will also discuss the pedagogical considerations put into the design of the content so that its digital characteristics are maximised.

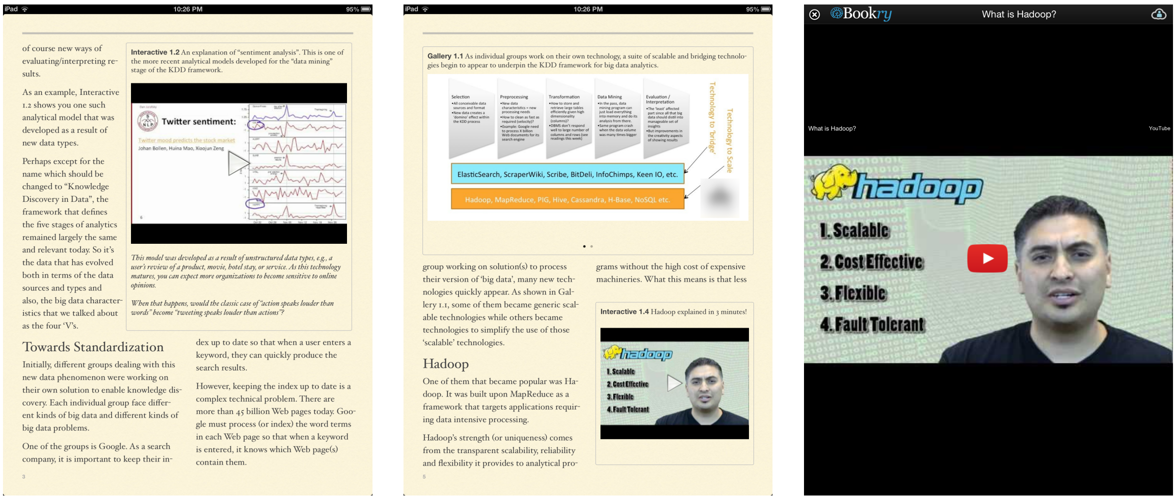
3.1 Overall Design

Our proof of concept was developed for a topic on “big data technologies” – an introductory unit for a postgraduate course. The majority of the cohort studies on-campus and are international students with a diverse range of first degrees. The majority of students in distant learning mode are young working adults looking to upskill their qualification. They also have varied first degrees and for the entire cohort, they do not have much knowledge about the topic being taught. The introductory unit teaches students three core data management areas, starting with an introduction to structured data via relational databases and SQL; followed by geographical and location-based information systems; and lastly, developments about “big data” and its applications.

We started by thinking about our target audience. We have ‘Gen-Y’ students whose learning habits are non-linear and highly visual (Saving, ; Schofield and Honor,). We also have distant learning adults who have family and work commitments and are therefore time poor. The design of the content must therefore take these situations into consideration. We decided to use visual and interactions liberally and create the content as small digestible ‘chunks’ to cater to the learning habits of ‘Gen-Y’. While we wanted “small chunks” of learning for the ‘Gen-Y’s, we were careful in how we collate material so that it doesn’t feel like a scrapbook, i.e., the ‘chunks’ should ‘gel’. We achieved that by having text as a narrative to the topic being discussed so that the ‘chunks’ are strung together in a logical fashion. Having the narrative is important for the distant learners because many of them lack the classroom environment to construct the narrative that on-campus students would otherwise have. We kept the text brief but nevertheless sufficient to satisfy those who needed it, and those who prefer a constructivist (or linear learning) approach.

Figure 2(a) shows the first page of the topic. We used one of the built-in templates for this proof but it was sufficient to show how the content is professionally typeset. An immediate advantage of an electronic book is that one can easily jump between pages as shown in the base of Figure 2(b) or one can easily find information quickly via the built-in search as

[3] See *http://www.withheld-for-review.edu/*.



(a) (b) (c)

Figure 3: More exemplars of widgets in action: (a) a widget (from *Bookry.com*) that can stream videos from YouTube is used here as a supplementary material (non-core) giving instructors the benefit of not having to reinvent what is already available; (b) another example of using the video but in this instance, the video provides an alternative explanation to the term ‘Hadoop’ to aid learner’s learning; (c) the video can be played full-screen in either orientation.

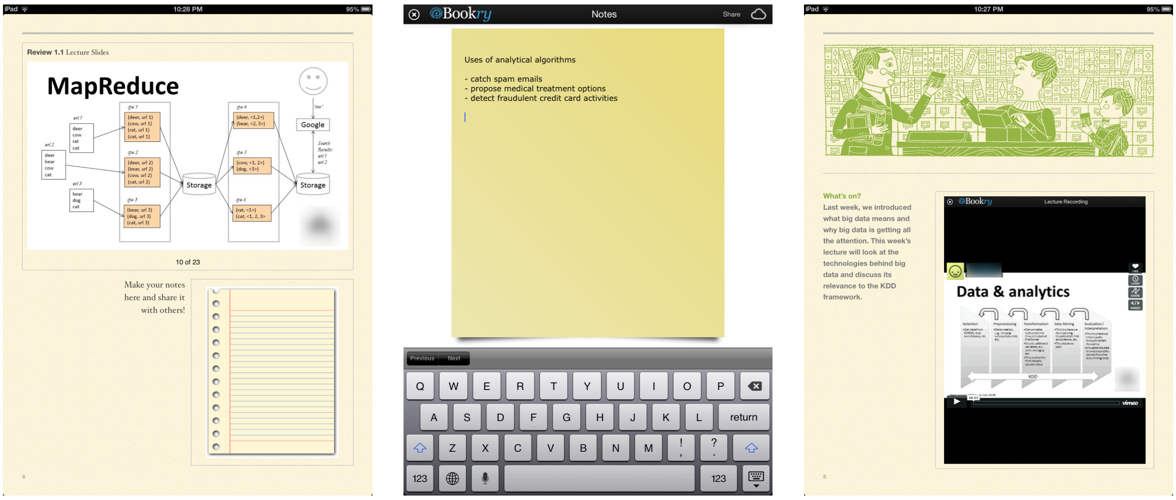
shown on the top of the same figure. These are important features for our learner and is something that printed textbooks cannot provide. In keeping with the goal of having learning material in “small chunks”, we achieved it through the use of *widgets*. Figure 2(c) (to be discussed next) shows one of the widgets that instructors can use to best present a given material. From our experience with the proof of concept, we find widgets are a great way to help us achieve the bite sized content we seek.

3.2 Using Interactive Diagrams

If a picture tells a thousand words, the interactive diagram says it all. An interactive diagram within the eBook allows a learner to interact with it to unveil additional information. In traditional textbooks, a diagram is accompanied by paragraphs of text and are often littered with location phrases such as “the item in the top right corner”. A learner has to bounce between the text and diagram, which may not be productive to some. The interactive diagram relocates the discussion within the diagram itself. If an item in the top right is to be elaborated, a learner touches on it and its explanation appears. In doing so, we find the diagram becoming a self-contain learning ‘chunk’. A learner can simply focus on the diagram and completes the learning without having to move between the text and the diagram itself.

In the case of our proof (Figure 2(c)), we used the interactive diagram to help discuss components of the data mining framework. One additional advantage that we discover during the creation of this diagram was how the limited space we have for elaboration actually forces us to think about what we want to communicate to our learners. Granted that this is an implicit expectation, traditional approaches of writing a textbook doesn’t necessarily have mechanisms to stop us from “getting carried away”.

Interactive diagrams are a great way to learn for our ‘Gen-Y’s who prefer interaction during learning (Saving, ; Schofield and Honor,). We also think that the interaction keeps them engaged longer, which if you recall in Section 2 is not a forte of the LMS. And with the design of this widget, we find that a learner is free to explore parts of the diagram in any order. This non-linearity of learning provided the freedom for our ‘Gen-Y’ students to construct their own learning. For the constructivist learners, the narrative in our eBook would provide the necessary overview and we see the diagram reinforcing a concept with more depth. And lastly for our time poor students, the short narrative would allow one to quickly gain an overview from the text and subsequently visit the details at a later stage. They can do so productively because they know precisely where the information is located. Contrast this to the LMS, where one searches multiple documents spread across ‘folders’ and when the document is found, the learner has to find the information hidden among paragraphs of texts.



(a) (b) (c)

Figure 4: Exemplar of using the *Gallery* widget: (a) to house lecture slides so that learners need not switch context to open slides; (b) the notepad screen in action when the *notes* widget in (a) was activated; (c) the video widget linking from *Vimeo.com* allowing the instructor to publish a lecture recording after class and the interactive eBook showing it when available.

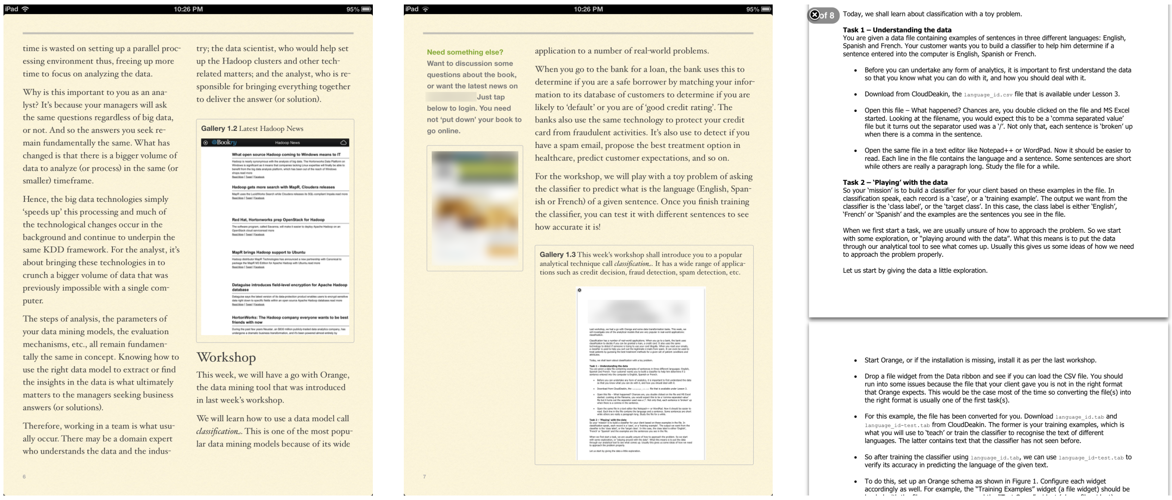
3.3 Using Sidebars

When developing our proof, we were concious of separating our content into 'core' and 'non-core' material. We see 'core' material as content that our learners must acquire and 'non-core' material as those that supplements the 'core' material. Not only does this distinction help instructors focus on what is essential in the delivery of the course, it also enables us to take advantage of external and ready-made resources for our 'non-core' components. In the LMS paradigm, an instructor may upload a mix of documents and hyperlinks to form the 'core' and 'non-core' material. Figure 3(a) is an example of how we used a sidebar to discuss a 'non-core' topic. In the text, we discuss various applications of big data citing "sentiment analysis" as one of them. If a learner is interested in knowing details of what "sentiment analysis" is about, he or she can simply visit the sidebar at any time to watch the video presentation.

This use of sidebar ensures that the main text is kept brief and to the point. It also means that a learner can easily visit the details about "sentiment analysis" on another occasion. In this case, rather than having to search for resources on the LMS (a common observation among the authors), the eBook offers an external resource embedded right within it thus, making it easily searchable. This satisfies learners who prefer to access relevant information when they want it. And for those time poor learners who simply want to know the essential, the separation enables them to quickly do so without having to spend time going through the content and making notes. The sidebar can also be used as a complement to the 'core' learning material. In Figure 3(b), we have an example where we explained the term "Hadoop". This time, we sourced an external video that also explains the term differently. In our example, this was a video that could be played right within the eBook environment as shown in Figures 3(a) and (b). We think this is an example of how the sidebar could be used effectively to help explain a concept that learners have difficulties grasping. Using an external resource that presents the concept differently not only helps the learner, it benefits the instructor in two ways. First, we could be more productive by sourcing external resources to help fill our need for an alternate pedagogy. Second, this approach increases opportunities for independent learning as learners can choose the option that suits. In turn, it reduces the need for individual consultation and frees time in the classroom to cover other material instead. While arguably the former could be achieved with the LMS, we think the later benefit is where the eBook truly delivers. That is, it allows content to be easily located and fulfill the benefits in future. By keeping content in one logical and searchable 'book', the eBook is a more attractive option than the LMS – for both learners and instructors.

3.4 Lecturing "from the Book"

From the beginning, we wanted the eBook to be *the* learning material *and* the frontend to a LMS. Usually, learners would be getting their learning material



(a) (b) (c)

Figure 5: Keeping content up to date is always challenging especially with computer related education: (a) here we provided basic concepts of 'Hadoop' while using a *RSS* widget to showcase the latest development news about the technology; (b) widget on the left of the page allows a learner access to the LMS directly from within the *iTextbook* so full functionalities are retained (c) using the *PDF* widget (shown lower right in (b)) to display PDF worksheets so that the desktop screen can be used solely for workshop exercises - this minimises the need for screen switching.

from the LMS in the form of PDF documents, lecture slides, and occasionally links to supplementary websites. So far, we have shown the use of two widgets: an interactive diagram and a video streamer. The later allows supplementary material to be embedded right within the eBook environment. This is important as it keeps the learner in a consistent environment rather than having to switch from one environment to the other with current LMS and links. So instead of static PDF documents, the eBook presents a variety of learning modes through the use of widgets.

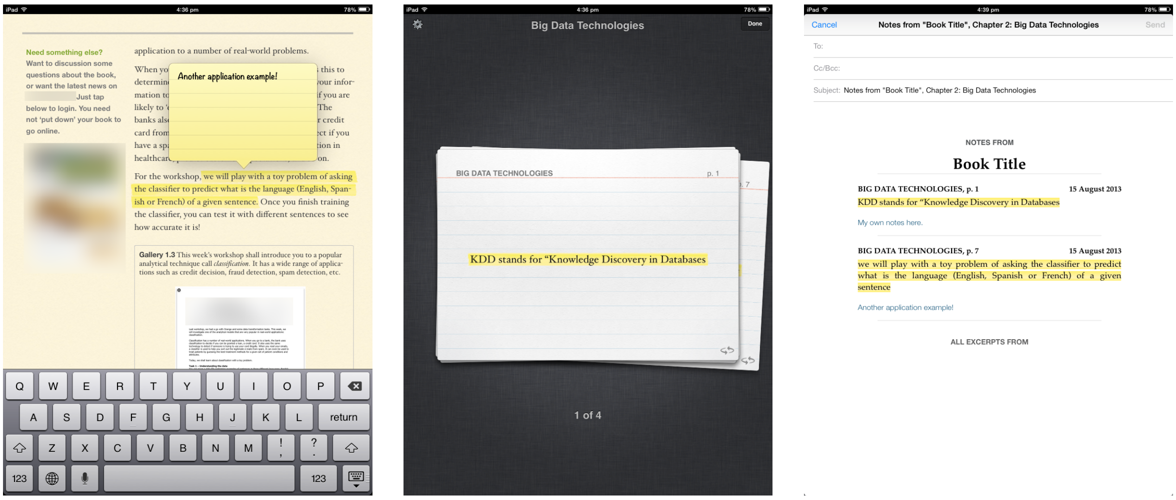
The other aspect of learning (in addition to the material) is the lectures and workshops. The conventional way to access lecture or workshop material is to download them from the LMS. We had a different approach by embedding them in the eBook. As learning material becomes increasingly open and accessible, we feel that there shouldn't be a need for learner to authenticate just to access material. If the sole purpose of authentication (with the LMS) is to track learner activities, then using the eBook would have provided the same information by using an appropriate widget. Better yet, having easy access to the lecture slides from within the eBook translates to (i) time savings from locating and downloading material; (ii) avoiding repeated authentications with the LMS and its components, e.g., iLecture, eLive, etc., and (iii) not having to navigate the inconsistent interfaces between them.

Our approach is to load the slides on a page as shown in Figure 4(a) so that when a learner attends a lecture, the slides are already available. During the lecture, learners can easily follow the slides and make notes by tapping on the *notes* widget to enter notes directly from within the eBook (Figure 4(b)) – another advantage over a LMS. Keeping one's notes with the instructor material means ready access to them regardless of where one is located. A learner could be on a public transport but since everything is on their device, they could easily revise or continue their learning on the go. There are not separate notes, MP3 devices or notebooks to deal with. After the lecture, a *video* widget as shown in Figure 4(c) could be used to revisit the lecture recording.

3.5 Content that Auto Updates

For many instructors, especially those in computer education, keeping content up-to-date can be a laborious task. Besides updating content for a new course run, instructors often have to deal with changes to a running course. An update translates to uploading new content to the LMS and then notifying learners of the change. For the learners, they will have to download the update and make sure that the right version of a PDF was saved. Clearly, the entire process is error-prone. For example, the learner might missed an update or a wrong version of the material was saved without knowledge.

The *RSS* widget in Figure 5(a) gave an insight into



(a) (b) (c)

Figure 6: Showcasing the other features of *iTextbook* for learning: (a) making notes from text within the eBook; and (b) later retrieving them as study cards for revision of salient points and also (c) the ability to share their notes with friends facilitates the collaborative team learning approach favoured by 'Gen-Y' learners.

the possibility of an evolutionary eBook, where content updates can be pushed automatically to learners. In our proof of concept, we used this widget to showcase how to manage topics that are still evolving. In this case, there are many developments in regard to 'Hadoop' and most likely, the content gets outdated very quickly. What we did was to use the *RSS* widget to source the latest news about 'Hadoop' and have it displayed. Now whenever the learner taps on the *RSS* widget, it will display the latest RSS feed about 'Hadoop' inside the eBook. A learner who wants to read more about a topic in the RSS feed simply taps on the widget to read the details.

Figure 5(b) shows a solution to ensure that learners get the latest version of a PDF. When an update is made on the LMS, the reader will no longer need to be notified. Instead when the *PDF* widget is activated, the latest version is automatically downloaded. In our example, we have a worksheet that teaches learners the use of a software. It might be that a new release appeared during the run of a course and learners have installed the newer version instead. An instructor may then be required to provided additional instructions in the worksheet and therefore, an update. With this widget, learners simply access the worksheet knowing that it will be the most recent. For those with work and family commitments, not having to deal with versions is an important welcome. Again, we find the LMS do not handle this as seamlessly as the eBook.

4 EVALUATION

We conducted a survey to evaluate the effect of iTextbook over LMS system. The study took place during the second trimester at Burwood campus of Deakin University, with assistant from teachers at the school. We targeted a cohort of hundred and eighty business and law students. The reason to choose business and law students is that we had more access to the resources and students as well as staff from this faculty willing to help us in this survey. Participants were first year undergraduate student from faculty of Business and Law. Although participants were in their beginning of undergraduate, majority of them had experience working with LMS (Desire2Learn) system at Deakin and had prior knowledge and understanding of the functionality of this system. The survey took place in six tutorial classes with the average of thirty students per class and we obtained valid data for forty-seven students who attended the tutorial class and experimented iTextbook. Although the proof of concept designed for IS subjects but we tested this subject of business and management students, our initial thought for doing it was that students with different background have more difficulty to understand the subjects that is not related to their study. Therefore, if they can learn from our iTextbook and understand the subject this might be a good sign that this style of learning is effective compared with LMS style of teaching.

The materials consisted of an iPad for every two participants with proof of concept downloaded on iBooks together with one set of questionnaire and plain language statement to present invitation and the purpose of this study from Universitys authorities. A questionnaire consisting of four sections was designed to understand and compare users satisfaction of LMS verses iTextbooks. Section A was designed to measure students satisfaction of Deakins Learning Management System and consisted of seven subsections that involved five open- ended questions and two subjective rating scale from N/A (Not Applicable) to Very Good. The purpose of open-ended questions in this section was to give a chance to participants to explain their reasons in details and scale rating questions used to measure their satisfactions level. In section B we concentrated on learning attitude of Deakin University students. In this section that consist of three sub-sections we used mixture of scale rating questions from N/A to Strongly Agree as well as multi-select and open-ended question. The scale-rating question used to measure how Agree or Disagree students are in responds to the statements. With multi-select question we found out what other tools students use for learning and the open-ended question asked participant to explain their reason of using select tools. The remaining two sections were designed to ask students idea regarding eBooks and using it as a frontend to Deakins LMS system. In section C participants answered questions about their perception of eBooks and online learning. Four different types of questions were asked from multi-select, close-ended, open-ended and scale rating. In question one we asked whether students ever used learning materials from an eBooks followed by comparison of their experience of eBooks compared with LMS system. In final section of our questionnaire we used set of questions to evaluate interactive eBooks as a complementary frontend to Desire2Learn system at Deakin University. Same as other sections we used range of different questions to ask participants idea. In this sections our questions mainly focused on comparison of LMS verses eBook and in what situations they prefer eBooks to LMS. The aim of the remaining questions was to ask students reason and their idea if they like to have other features added to eBook. In designing survey, we have considered Laurillards conversational framework to have a better understanding of conversation between learners and instructors by considering our iTextbooks on the middle of this relationship. In (Laurillard), learning is a dialogue communication facilitated through the use of some educational media. A media might be LMS, a virtual environment or in our case the iTextbooks. In this study, the adaptive factor is the feedback that students provide about the LMS at this institution (CloudDeakin) and the interaction is where instructors support the related tasks and experiences to the topic and topic goals.

5 RESULTS

In this survey the sample size of (n = 47) has been measured to confirm the research hypothesis. We asked students to rate the six features of the institution's LMS – CloudDeakin, from "Very Bad" to "Very Good" and where it doesn't apply to them, they can indicate "N/A". The six factors of measurements determined to have adequate model-data fit with $x^2 = 35.1$ for 20-degree of freedom, Chi-square per degree of freedom = 1.755, p-value = 0.0122, probability = 0.020 and RMSEA = 0.1267. We can observe that the $x^2 = 35.1$ is greater than the standard of Chi-square probability table which is 34.170. In other words, there is a significant similarity between the data observed and the data expected. To increase the accuracy level of this study we have not calculated the N/A responses in our Chi-square test. The majority of the students initial respond to the LMS system was positive. Thirty-four students out of forty-seven of them had good overall impression of CloudDeakin. Among them some mentioned, *There are good resources, lecture recording and notes* and others mentioned, *Many resources provided but not all are good.* Based on our analysis, 65.2% of students agree that CloudDeakin represent the modern way of student learning whereas, 6.5% are against this concept. Among other analysis, majority of students more than 52.2% spend more time learning on classrooms compared with 23.9% of them spend more time learning via lecture recording. Several other expressions on students learning habit concern that 45.7% of students search for other extra resources beside lecture notes for learning whereas, 29.3% of them relying on lecture notes only. The survey shows that 29.8% of students used eBook in the past whereas, 36.2% of them have never used an eBook as learning material. Further, 14.9% of them have never heard of eBook and 10.6% of them are not interested to use any form of eBook as learning material. From the lower percentage of students who used eBooks before, the survey suggests that many are not aware of the capabilities of an eBook compared to the LMS, where all already had experience in. Inferring this further, it also means that students need to be introduced about eBook benefits prior to any broad usage if the technology is to have any chance of success.

Our survey also asked if our participants have used other learning tools besides the iTextbooks and a typical LMS. The survey listed tools such as, MITx (MIT

OpenCourseWare), Coursera, Stanford, ITunesU and Khan Academy. The intent of this question is to understand if students seek and use other learning sources besides the university provided material. Out of the forty-seven participants, about 76.6% of them have ever heard of the alternative tools that we listed; and 36.2% of them have tried those tools at least once in the past. Over questions about 'knowing' and 'using' a listed technology, our respondents do seem to read or hear about the technology but aren't proactive in trying anything new. Perhaps this was due to their preference of more established approaches of the classroom and LMS, or they are content with what was already provided to the them.

In terms of the survey details, 10.6% reported that they have heard of MITx and 2.1% of them have tried this tool; 6.4% of them have heard of Coursera but only 2.1% of them have used it in the past. Stanford Online was reportedly known by 19.1% of our respondents but only 4.3% of them have ever used it; 27.7% of them heard of iTunesU and as expected, a smaller percent of them have used the tool (14.9%). Khan Academy reported the best result between 'knowing' and 'using', where the 12.8% of respondents who reported about 'knowing' it have all used the tool as well. That said, iTunesU had the highest attention and use among other tools by absolute numbers but we think this was more due to the app's association with a commercial entity.

Khanh Academy is an interesting one as there are obvious similarities to an LMS. First, both of them are Web-based applications and there is a simple mouse-click interaction between system and users. Second, administrators design both systems and users have to follow the rule that asked them to follow. This finding is giving us another insight that similar systems such as LMS and Khanh Academy might be the systems learners trust as their learning tool at this stage of technology growth.

Our survey also asked respondents to compare the iTextbook experience against CloudDeakin. Of the 83% who answered relevant questions, 36.2% of them prefer eBook compared with 25.5% of them who prefer CloudDeakin. Among them, 21.3% of them prefer both systems equally. These numbers are interesting because they suggest that while students are happy with their LMS, they are also interested in having an eBook as a way to access their LMS hosted material. From the qualitative comments, we can see that students find the eBook's mobility an added convenience to have. Just as the LMS extends learning in ways beyond the classroom, the eBook will add to the repertoire of learning tools that a learner will have.

6 REFLECTION

The experience in developing this eBook has given us a lot of insights into the possibilities that are present to both instructors and learners.

For us the instructors, using *iBooks Author* feels more like writing an academic paper on a subject matter that we are familiar with; whereas the interaction with the LMS felt like an administrative activity. From time to time, having to navigate the different components and adjust content presentation to fit the LMS structure left us wondering if the extra effort delivers any benefits for either the instructor or the learner. After all the 'trouble' at the expense of the instructor, the learner has to navigate the nested 'folders' of the LMS before one can commence learning. In the case of the eBook, not only is the knowledge transfer process familiar to the instructor, the skeuomorphic design of the eBook ensures that the learner can immediately navigate and access content without problems. We think this is important because the learner can focus on learning when he or she is less concious of the interaction that is taking place. This is not so in the case of using a LMS, where each interaction is met with a pause to the server and access to material is subjected to changing context, such as a different software application being started or a different window been shown.

The above being said, we agree that the LMS is more than just a repository of content. We acknowledge the many other capabilities it carries (e.g., student and course management). Indeed where administration and control is required, LMS is the way to go. However, we believe learning is the opposite of control and structure projected by the LMS; at least for our learners. We believe learning is about acquiring knowledge in a way that suits the learner, i.e., it should not be a single rigid approach. On this front, the user interface and the design of the content align well to the different learning profiles that we are aware of. Another important feature that we have yet to discuss is that the eBook enables learners to connect with one another. Given that our learners prefer learning in a collaborative and team setting, having the ability to tweet or post a status update is crucial. With the right widgets, the eBook can do just that without switching context, application, or windows. In Figure 4(b) for example, the notes can be synchronised to a cloud storage and then shared with other parties. The *iTextbook* also includes native features that allow learners to build their own study notes and then email it to their friends. These built-in features as shown in Figure 6 will be a step in the direction of collaborative learning. In fact, third party widgets such as those from Bookry (*http://www.bookry.com*) are already offering advanced social-networking capabilities. For the 'Gen-Y's who prefer to learn in teams and are constantly connected, they are likely to welcome such features.

7 CONCLUSIONS

The result provides a rich set of observations to guide future research and development. We found that majority of students are satisfied with the way that CloudDeakin is performing and the service that LMS system provide for them. Moreover, the result indicates more than half of the student find out LMS as a modern way of learning despite they have experimented our iTextbook. However, this achievement is in contrast with our initial hypothesis about LMS system. We assumed LMS is not a user-friendly system for students with no mobile-friendly interface whereas our survey result can show students are toward LMS system. On the other hand, we found out still more than half of the students prefer traditional ways of learning or computer/laptop devices as a learning tool which is in contrast with our initial assumption that students prefer to use their mobile devices as a learning tool. On the other hand, once it comes to final comparison between LMS and eBook majority of students have no answer to this question and the rest of them prefer eBook to LMS system. This observation giving us the second insight that we might use eBook and LMS as supplement to one another.

Indeed from our own reflection, the future of LMS*es* appears to be stuck in between a rock and a hard place. On one hand, we have learners who are embracing mobile devices and ecosystems that LMS vendors have no control of. This will only reinforce the LMS as a system that is *not* learner centred and consequently, risk ending up as a system for administrators. On the other hand, LMS*es* are facing competition from non-traditional players. On the iOS platform for example, the *iTunes U Course Manager* (i.e., backend; *https://itunesu.itunes.apple.com/coursemanager*) and the *iTunes U* app are already replicating the basic functions (content hosting and delivery) of a LMS. Also not to forget, the content delivered is done with high fidelity through components such as the *iTextbook* discussed in this paper. Outside of the iOS eco-system, Microsoft's *SharePoint* (*http://www.sharepointlms.com*) and Google's *Open Course Builder* (*https://code.google.com/p/course-builder*) are also attracting attention as LMS alternatives. So while we are unsure of how LMS*es* will develop, we do know that it will be influenced by the developments in m-Learning, i.e., the expectations of learners, new technological developments, and new learning paradigms.

ACKNOWLEDGEMENTS

The conduct of the survey and the handling of its data has been approved by Human Research Ethics Committee, Deakin University (BL-EC 17-13). The authors also wish to thank the School of Information & Business Analytics for funding part of the work reported in this paper.

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An Exercise Assistant for Practical Networking Courses

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Keywords: Virtual Lab, e-Learning, Exercise Assistant, Networking Exercises, Description Logic.

Abstract: Supporting students with feedback and guidance while they work on networking exercises can be provided in on-campus universities by human course advisors. A shortcoming however is that these advisors are not continuously available for the students, especially when students are working on exercises independently from the university, e.g. at home using a virtual environment. In order to improve this learning situation we present our concept of an exercise assistant, which is able to provide feedback and guidance to the student while they are working on exercises. This exercise assistant is also able to verify solutions based on expert knowledge modelled using description logic.

1 INTRODUCTION

Computer science curricula for students at universities nowadays include courses on networking and information technology security. Teaching theory on networking and IT security is usually done by means of textbooks and classes (either face-to-face classes or virtual classes, which are popular at universities for distance education). To anchor and deepen the acquired theoretical knowledge, a commonly used teaching method is to hand out practical exercises. The exercises can be worked out in a computer lab, which can be either a traditional on-campus lab or a virtual lab.

Recent evaluation shows that students of a traditional on-campus networking course deem it crucial for their learning success to be able to get support from a course advisor (Haag et al., 2013). While an on-campus university will be able to provide course advisors which can support students in so-called guided learning hours, this support is no longer feasible if students work e.g. at home in the evening hours using a virtual lab.

In this paper we introduce an exercise assistant for networking courses which is able to support students while they work on networking exercises. Equipped with a formal model of an exercise, the exercise assistant can be run on a student's computer whenever and wherever support is needed. The effort to author such an exercise has to be done once while instances of the exercise assistant equipped with this exercise will then be able to support any number of students.

The paper is organized as follows: First we introduce our current learning environment in chapter 2 and an example exercise in chapter 3. In chapter 4 we explain our formal model of an exercise. This formal model can be processed by our exercise assistant, whose software architecture we introduce in chapter 5. After giving a guiding example in chapter 6 we conclude our work in chapter 7.

2 VIRTUAL LAB

The virtual computer security lab (VCSL) is a stand-alone environment that each student can install on his or her local computer (Vranken and Koppelmann, 2009). It is composed of two virtualization layers, as shown in Figure 1. The host machine is the student's computer, which runs an arbitrary operating system, i.e. the host operating system. The first virtualization layer creates the virtual host machine. It consists of virtualization software such as VMware Player or Oracle VirtualBox, which runs on the host machine just like an ordinary application. Virtualization software in general introduces an additional software layer with corresponding interface, which creates a logical abstraction from the underlying system software and hardware (Smith and Nair, 2005). Versions of this software are available for free for a large range of platforms and therefore run on nearly all student computers, regardless of the hardware and the host operating system.

The virtual host machine runs the guest operating system. For the VCSL, Linux was selected, since it is open source and can also be distributed to students without licensing costs.

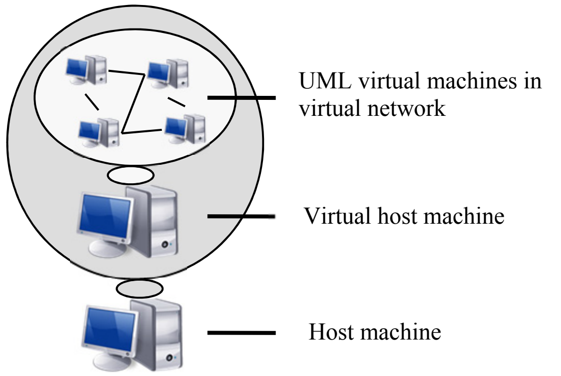

Figure 1: Architecture of the VCSL.

The second virtualization layer is a Linux application, called Netkit (Pizzonia and Rimondini, 2008), which runs inside the virtual host machine. This layer allows to instantiate multiple virtual machines that all run Linux. Netkit applies virtualization based upon User Mode Linux (UML). A UML virtual machine is created by running a Linux kernel as a user process in the virtual host machine (Dike, 2006). Multiple UML virtual machines can easily be run simultaneously, while using minimal resources. The file system is shared by all UML virtual machines using the copy-on-write (COW) mechanism. Hence, the file system is shared read-only by all UML virtual machines. Each UML virtual machine has a second, separate file system in which only the local changes to the shared file system are stored. This saves both disk space and memory, and simplifies management of multiple UML virtual machines. Restoring an initial clean system means to simply remove the second file system.

The VCSL was further developed (Vranken et al., 2011), (Haag et al., 2011) into a distributed VCSL (DVCSL). This DVCSL enables students to work together in a virtual lab by connecting their labs, even if they are physically distant from each other by using an interface to the Netkit environment. This interface consists of a Ghost Host and a Remote Bridge. While the Ghost Host was developed to extract and inject network packets when connected to an existing Netkit virtual network, the Remote Bridge is able to send and receive this packets using an intermediate connection network, e.g. the internet. Using this interface, local Netkit networks can be connected in a transparent and secure manner although they reside on different, distant students' computers.

This decentralized approach is suited to accommodate any number of students and offers students freedom to run the lab whenever and wherever they want, while preserving the properties of a conventional computer lab (e.g. the isolated network). Therefore, this approach is not limited to distance teaching but could also be useful for universities using a conventional computer lab.

3 EXAMPLE EXERCISE

An example assignment of a practical networking course to be solved using the VCSL environment is:

"Setup and configure a scenario with at least three hosts (client, router, server). Client and server should be located within different subnets. The client should be able to intercommunicate with the server by using the intermediate router. The routing should be based on static routing tables."

The minimal requirement for this setup is shown in Figure 2, consisting of at least three hosts. The client and the server have one network interface card (NIC); the router is equipped with two NICs; one for the client network named *n1* and one for the server network *n2*. Each NIC of each host has to be configured with a valid network configuration.

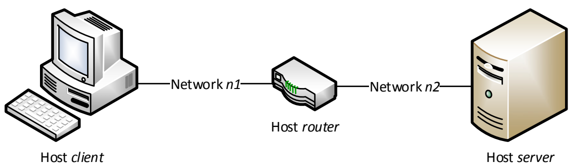

Figure 2: Valid concept draw for the example assignment.

In this example exercise, students will have to set up hosts and interconnect them accordingly within two different networks. They will then have to assign appropriate IP addresses to these hosts and ultimately configure the routing by altering the routing tables on the hosts. Once the setup is configured properly, students can demonstrate the validity of their solution, e.g. by sending network packets between client and server.

A valid and straightforward solution for this example networking assignment solved in Netkit is stated in Table 1.

Table 1: Valid solution using Netkit.

```
# Create the hosts and networks in Netkit
vstart client --eth0=n1
vstart router --eth0=n1 --eth1=n2
vstart server --eth0=n2
# Assign IP address on the client
ifconfig eth0 10.0.0.1 up
# Assign IP address on the router
ifconfig eth0 10.0.0.2 up
ifconfig eth1 11.0.0.2 up
# Assign IP address on the server
ifconfig eth0 11.0.0.1 up
# Set default gateway on the client
route add default gw 10.0.0.2
# Set default gateway on the server
route add default gw 11.0.0.2
# Connection test on client to the server
ping 11.0.0.1
```

4 EXERCISE MODELLING

In the following chapter we show how the exercises can be transferred into a formal representation, in order to be processed by a computer program. First we will show the partition of our example exercise into activities that will then be organized in a graph structure. This graph will then be extended with conditions that will make the activities verifiable. We also show a way to add feedback attributes to the graph in order to model a certain feedback strategy. Finally we introduce probing, a mechanism to improve the verifiability of activities.

4.1 Activities

Typically, exercises will start with an empty lab. Students have to perform activities that result in a working network environment, configured according to the requirements of the given exercise. While Table 1 shows the commands needed to solve the exercise in Netkit, the minimal conceptual activities needed for solving this exercise are listed in Table 2.

While A10 is the final activity, the order of the activities A1 through A9 shows only one possible sequence. The order can vary because some activities are independent from each other (e.g. A1 and A2), while some other activities have interdependencies (e.g. A1 is a precondition for A3).

These activities and their interdependencies can be modelled as an acyclic, directed graph with exactly one sink (node N with outdegree(N) = 0) and at least one source (node N with indegree(N) = 0).

Table 2: Activities needed to solve the example exercise.

Activity	**ID**
The client network has to be created.	A1
The server network has to be created.	A2
The client has to be connected to the client network and an appropriate IP address has to be assigned.	A3
The server has to be connected to the server network and an appropriate IP address has to be assigned.	A4
One NIC of the router has to be connected to the client network and an IP address from the client network has to be assigned.	A5
One NIC of the router has to be connected to the server network and an IP address from the server network has to be assigned.	A6
The client has to be configured to use the router's NIC in the client network as default gateway.	A7
The server has to be configured to use the router's NIC in the server network as default gateway.	A8
Routing has to be enabled on the router.	A9
Client and server must intercommunicate via the intermediate router using the IP protocol.	A10

Activities are represented by nodes. A precondition is modelled as a directed edge from the predecessor to the successor, seamlessly indicating the order of the activities. The final activity will be represented by a sink. Activities without a precondition will be represented by sources.

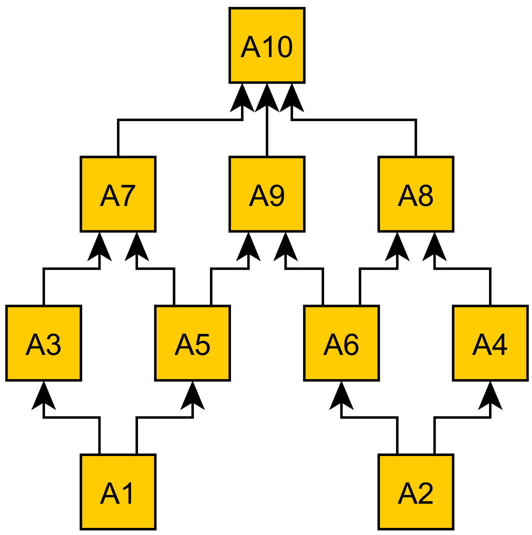

Figure 3: Example graph.

A valid graph for our example exercise is shown in Figure 3. This graph is based on the activities stated in Table 2. The interdependencies and thus possible sequences of activities show a valid example. These can of course vary, depending on the exercise and the author's intent, too.

4.2 Conditions

In order to process the graph, the activities have to be verifiable. That means that a condition is needed to detect or to decide, whether an activity is deemed passed, i.e. whether the student has successfully solved a part of the exercise.

In (Haag, Karsch, Vranken, and Van Eekelen, 2012) we showed, that network packets, obtained from the student's Netkit lab, can be used to detect and verify network properties and behaviour of an Ethernet based network. By modelling network specific expert knowledge as predicates and verifying these predicates using the captured network packets, it is possible to detect e.g. the presence of certain hosts and also routing behaviour. While the prototype in (Haag, Karsch, Vranken, and Van Eekelen, 2012) demonstrated the technical feasibility of that approach by using SQL queries to model predicates, we improved on it by using description logics (Baader, Calvanese, McGuinness, Nardi, and Patel-Schneider, 2003).

For the terminological box (TBox) we created a network ontology for Ethernet based networks, representing the network layers 2 and above (Tanenbaum, 1985), including but not limited to the header and payload fields of the most commonly used protocols, e.g. Ethernet (RFC1042), ARP (RFC826), IP (RFC791), TCP (RFC793) and UDP (RFC768). In addition, we added a unique identifier for each packet and the network origin. An excerpt of our ontology for Ethernet networks is shown in Figure 4.

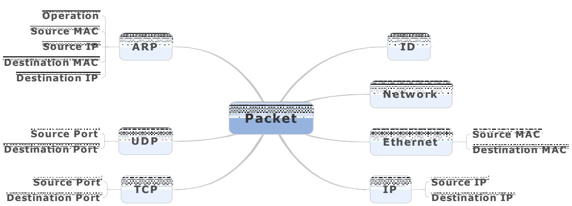

Figure 4: Ontology excerpt for Ethernet networks.

Using this ontology it is possible to model expert knowledge as predicates using a logic programming language, e.g. Prolog (Colmerauer and Roussel, 1993). For example, the expert knowledge to describe the network behaviour "routing" according to (Haag, Karsch, Vranken, and Van Eekelen, 2012) is:

"*Routing occurs if an OSI layer 3 IP transmission of a network packet between two hosts is based on more than one OSI layer 2 transmissions*".

The technical background is shown in Figure 5. The client wants to communicate with the server using the IP protocol, but the server is located in a different network segment. Direct inter-communication between client and server is not possible because the underlying Ethernet protocol does not support communication over network borders. The client has to use a known router located in the same network as itself, and thus reachable by Ethernet. The client now sends an IP packet addressed to the IP address of the server, but the underlying Ethernet packet will be addressed to the router. When the router does receive such a packet, it will forward it to the server. While the two packets that the client and the router send do not differ on the IP layer (both are sent from the client, and addressed to the server), both differ on the Ethernet layer, with different source and destination MAC addresses.

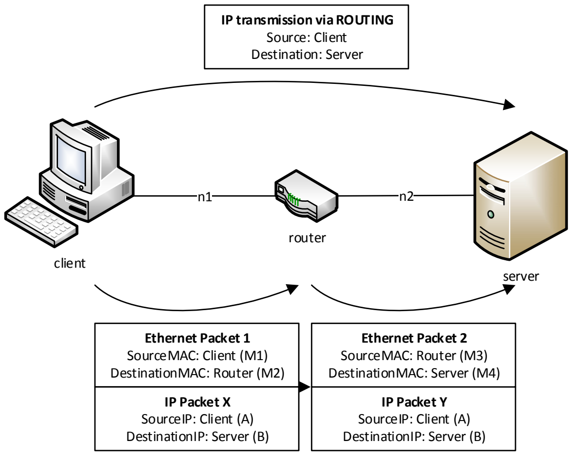

Figure 5: Routing packet flow example.

Based on the Ethernet network ontology, this behaviour can be expressed as the following Prolog predicate:

```
routing :-
   ip_packet(X,A,B),
   ip_packet(Y,A,B),
   ethernet_packet(X,M1,M2),
   ethernet_packet(Y,M3,M4),
   M1 \= M3, M2 \= M4.
```

This predicate can be read as "routing occurs, when there are two IP layer packets X and Y, both sent from IP address A to IP address B, for which the source and destination addresses differ on the Ethernet layer.”

Predicates can be used as conditions to detect activities. E.g. the predicate 'routing' can be used to verify the activity A10. We extended the graph, so that every activity can be associated with a condition to verify that activity.

Routing is only one example. We successfully created predicates describing e.g. the presence of hosts and networks, the network behaviour NAT or routing and also higher level usage. E.g. ARP spoofing behaviour can be detected if two hosts within the same subnet having different MAC addresses pretend to own the same IP address using the ARP protocol. However, this behaviour can also be caused by a misconfiguration of the hosts. For that reason this condition requires preconditions to verify a valid and error-free setup.

We also found a trade-off between the shape of an assignment and the capabilities to design predicates. If the assignment is more tightly controlled (e.g. predefined network names and IP addresses), more precise predicates can be designed to detect activities. If the assignment is more generic, the predicates also have to be designed in a more generalized manner.

4.3 Feedback

There are various types of feedback strategies which can be used to support students working on the exercise, e.g. suggestions, complete guiding or an exam mode. The specific shape will be either customized to match the author’s aims or customized to the learning style of the learner or a combination. Usually recent progress the student has made in the exercise graph should trigger interaction with the student according to the feedback strategy.

Therefor we extended the graph with feedback attributes. The graph as a whole can be associated with an attribute containing the exercise description; all activities can be associated with different attributes for feedback control, i.e. text messages that give hints about what the next activity might involve (pre messages), or text messages that give feedback about detected activities (post messages). An example for activity A1 from our example exercise look like this:

```
pre_message = "You will need at least one host connected to network 'n1'."
post_message = "Network 'n1' detected."
```

While our message mechanism provides the technical means for the implementation of various feedback strategies, the evaluation and choice of an appropriate strategy resides with the exercise author.

4.4 Probing

While the verification of activities based on passively observed network packets works for many activities, there still are limitations. One such limitation occurs, when an activity needs to be verified that does not have immediate results in the form of network packets.

An example for that would be A9 from our example exercise: the routing functionality has to be activated on the router. Students can do that by setting the appropriate kernel flag on the router if this flag is not enabled by default. This however will not result in the occurrence of observable network packets, until packets are sent to the router for being routed. A possible solution would be to ask the student to send appropriate network packets himself. We followed a different approach. For detecting certain activities we inject special predefined network packets into the Netkit environment to provoke a certain predictable behaviour. This behaviour can also be expressed as a predicate. In the routing example we inject an Ethernet packet addressed to the router into the client network that is addressed to a host in the server network (which does not have to exist) on the IP level. If routing is enabled in the router, the router will try to reach that host in the server network using ARP requests. These packets can be used to verify that routing is indeed enabled on the router.

Such a “probing” packet can be assembled by strictly following the network stack, starting with an Ethernet frame. The destination MAC address must be the router’s NIC connected to network *n1*. In Netkit, the MAC address of a network interface is bound to the name of the client, resulting in a predictable MAC address for the router’s first NIC eth0: 0a:ab:64:91:09:80. The source MAC address can be virtual, e.g. ee:ba:7b:99:bc:a5, followed by an IPv4 ethertype identifier (0x0800). The encapsulated IP packet starts with the version identifier (0x4), followed by mandatory header fields, e.g. length and checksum. The source IP address can be virtual but should be located within the IP range of network *n1*. The destination IP address can also be virtual but must be part of subnet *n2*. The IP packet encapsulates an ICMP echo request just to get a complete and valid network packet. This customized packet layout can be represented by a hexadecimal character array, e.g. `0aab64910980eeba7b99bca508004500001c12344000ff01549c0a0000010b0000100800f7fd00010001`.

We extended the graph, so that every activity can be associated with a custom network "probing" packet to be sent once before verifying its condition. While that actively alters the environment, it enables the verification of additional activities.

5 EXERCISE ASSISTANT

In order to support a student while working on an exercise, we developed an exercise assistant, which can be used in the VCSL. As shown in Figure 6, the exercise assistant is composed of three components: reasoning engine, feedback engine, and an interface to the student's working environment called Netkit interface.

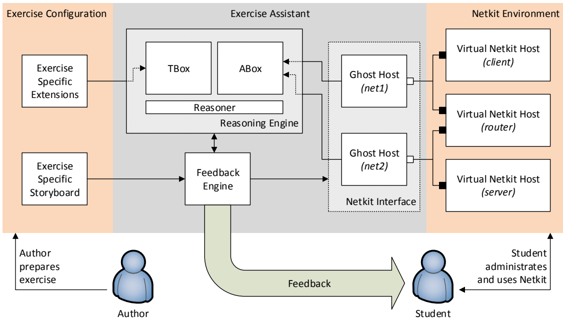

Figure 6: Architecture of the Exercise Assistant.

The reasoning engine itself is composed of a reasoner and a knowledge base, which contains a TBox ("terminology box") and an ABox ("assertion box"). The TBox contains knowledge about the domain, i.e. our ontology, in the form of predefined predicates that can be extended by the author with exercise specific extensions, while the ABox contains the concrete instantiations.

The data in the ABox is obtained through an interface to the "real world", in our case the Netkit interface. The Netkit interface consists of one or more Ghost Hosts (Vranken, Haag, Horsmann, and Karsch, 2011) that record network packets from their respective Netkit network, extract the information in them and store that information in the ABox. The Ghost Hosts can also be used to inject special network packets into the environment.

The feedback engine is the part where the activity graph will be processed. Our exercise assistant is able to read an exercise graph stored in the GraphML (Brandes, Eiglsperger, Herman, Himsolt, and Marshall, 2002) format. Once read, the activities are continuously processed according to their interdependencies, starting at the source nodes which represent activities without preconditions. Processing the activities in this case means verifying their conditions and giving the student feedback according to the feedback attributes of that activity. Once the activity is completed it will be removed from the graph and thus as a precondition for its successors. The feedback engine can also use the Netkit interface, respectively the Ghost Hosts, to insert custom network packets into the environment in order to provoke certain network behaviour to verify an activity's condition using the reasoning engine.

The Exercise Assistant is a software program written in the programming language C using SWI-Prolog (Wielemaker, 2009) as the reasoning engine.

6 EXAMPLE

Using the VCSL, the window layout of the desktop presented to the students looks like Figure 7. The exercise assistant shell is a window where the student can keep track of the feedback generated by the feedback engine. The linux shell is a window where the student is able to administrate and use Netkit in order to e.g. create hosts and networks. Once a host is started, it will open a respective shell enabling the student to administrate the host itself. Further hosts, e.g. the router and the server, will open respective shells, too.

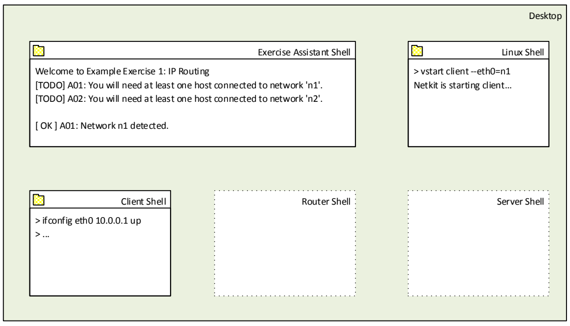

Figure 7: Desktop draft.

The following figures are screenshots taken from the exercise assistant shell guiding the example exercise. We authored the activities of table 2 according to the exercise graph of figure 3 and added verbose feedback. The introduced routing predicate is used to verify the final activity (A10). The intermediate activities too have been modelled using our ontology, partially by utilizing probing packets.

Once started, the exercise assistant introduces the exercise by displaying the exercise description.

Starting with the activities without precondition (A1 and A2), the exercise assistant will prompt the student using the respective `pre_messages`.

```
Example Exercise 1: IP Routing

Setup and configure at least three hosts (client, router, server). Client and se
rver should be located in different networks. The client should be able to inter
communicate with the server by using the intermediate router. Verify your routin
g environment by sending routed network packets between client and server.

Please name the network(s) and the host(s) according to the diagram below.

Diagram:
        +------+             +------+             +------+
        |client| <-----n1-----> |router| <-----n2-----> |server|
        +------+             +------+             +------+

IP addresses:

         client                  router
        10.0.0.1 <-----n1-----> 10.0.0.2
                                    |                  server
                                11.0.0.2 <-----n2-----> 11.0.0.1


Good luck!

[TODO] A01: You will need at least one host connected to network 'n1'.
[TODO] A02: You will need at least one host connected to network 'n2'.
```

The student can start solving the exercise according to Table 1. After the first command `vstart client --eth0=n1` is entered using the linux shell, the exercise assistant is able to confirm this valid activity.

```
[ OK ] A01: Network n1 detected.

[TODO] A02: You will need at least one host connected to network 'n2'.
[TODO] A03: Please configure the NIC of the client.
[TODO] A05: Please configure the router's NIC connected to 'n1'.
```

While A1 is being marked as verified, using the respective `post_message` of A1, the remaining independent activities without preconditions will be displayed again, superseding the preceding messages. According to the exercise graph, the student is now able to choose A2, A3 or A5 as the next activity. Starting the router connected to network *n1* and *n2* results in a verified presence of *n2*.

```
[ OK ] A02: Network n2 detected.

[TODO] A03: Please configure the NIC of the client.
[TODO] A04: Please configure the NIC of the server.
[TODO] A05: Please configure the router's NIC connected to 'n1'.
[TODO] A06: Please configure the router's NIC connected to 'n2'.
```

While the presence of the two networks is verified now, the exercise assistant is not able to detect whether the student has started the server, unless its network interface card gets assigned an IP address. Therefore the `pre_messages` are authored to prompt the student properly.

Choosing to assign the client's IP address as next activity, using the command `ifconfig eth0 10.0.0.1 up` in the client shell, will result in a verified activity A3.

```
[ OK ] A03: Client host with IP address 10.0.0.1 detected.

[TODO] A04: Please configure the NIC of the server.
[TODO] A05: Please configure the router's NIC connected to 'n1'.
[TODO] A06: Please configure the router's NIC connected to 'n2'.
```

Still missing IP addresses of router's and server's NICs, the student can proceed to configure the router's NICs.

```
[ OK ] A05: Router's NIC with IP 10.0.0.2 detected.

[TODO] A04: Please configure the NIC of the server.
[TODO] A06: Please configure the router's NIC connected to 'n2'.
[TODO] A07: Please adjust client's routing table to use the router.
```

```
[ OK ] A06: Router's NIC with IP 11.0.0.2 detected.

[TODO] A04: Please configure the NIC of the server.
[TODO] A07: Please adjust client's routing table to use the router.
[TODO] A09: Ensure, that the router is able to route packets.
[ OK ] A09: Router acts as a router between n1 and n2.

[TODO] A04: Please configure the NIC of the server.
[TODO] A07: Please adjust client's routing table to use the router.
```

Having verified that the two NICs of the router are present, the exercise assistant is able to verify A9 using a probe packet. For the simple reason that routing is enabled per default for hosts in the Netkit environment, the condition of A9 can be verified immediately.

```
[ OK ] A04: Server's NIC with IP 11.0.0.1 detected.

[TODO] A07: Please adjust client's routing table to use the router.
[TODO] A08: Please adjust server's routing table to use the router.
```

After assigning an IP address to the remaining NIC of the server, the student has to alter the routing table on the client and on the server. The exercise assistant is also able to verify these activities by using probing packets.

```
[ OK ] A07: Client uses router as gateway to 'n2'.

[TODO] A08: Please adjust server's routing table to use the router.
[ OK ] A08: Client uses router as gateway to 'n1'.

[TODO] A10: Finally, show me that client and server can intercommunicate.
```

Finally, the student is asked to demonstrate the routing functionality by sending packets between the client and the server using the intermediate router. One valid solution is to use the command *ping*.

```
[ OK ] A10: Setup verified, exercise completed.

[DEBUG] Solved in 7 minutes and 42 seconds.
[ OK ] Finished! Well done!

vmware@ubuntu-vm:~/Entwicklung/svn/current/jens/eca-pl-dev/eca-pl-dev$
```

Once the final activity is verified, the exercise assistant congratulates the student and then quits.

7 CONCLUSIONS

We presented an exercise assistant which improves the learning situation of students solving practical exercises in a networking course. Even when human course advisors are not available, our exercise assistant can recognize learning progress and provide appropriate feedback and support. This significantly improves the learning situation for students working remotely in a virtual environment, which is common at universities for distance education. Besides this automatic support, the exercise assistant can verify intermediate and complete solutions of an exercise.

We also presented an approach to formally model exercises in a manner processable by the exercise assistant. For that purpose the exercise author can define possible activities and sequences using a graph structure. Description logic is used to define conditions for the verification of these activities. The exercise author is also able to define a feedback strategy by adding feedback attributes to the graph.

Especially for courses with many participants, our experience shows that teaching staff can benefit from utilizing the exercise assistant. While the teaching method of tutors personally and individually supporting students is certainly one of the most effective for knowledge transfer, it is not feasible for courses of sufficient size. In such scenarios, the exercise assistant can e.g. be used to offer all students a basic guided tutoring support not only wherever and whenever they want, but also at the speed that best suits their own learning style and their own abilities.

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MOOCs for Universities and Learners
An Analysis of Motivating Factors

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Keywords: MOOCs, Education Disruption, Motivations for Learning, Institutional Strategy.

Abstract: Massively Open Online Courses (MOOCs) are a recent introduction to the palette of educational offerings yet in a short time they have become the subject of massive interest and hype. There are those that predict that these free courses are the first ripple in the coming wave of disruption that the web and on-line education will cause to traditional universities. However University investments in producing MOOCs are increasing exponentially and at the same time learners are enthusiastically registering in their tens of thousands for these courses. This paper describes some research into the motivations for universities to create MOOCs and the motivations of learners in registering and completing them. Our results show a spectrum of motivations for universities, and suggest a need for individual universities to be clear of where they sit in that spectrum. For students we see that motivations can vary significantly across cultures.

1 INTRODUCTION

In September 2013 the first UK based MOOC platform, FutureLearn, announced its first batch of twenty MOOCs. These MOOCs ran in the final quarter of 2013 and included the University of Southampton's first MOOC "Web Science: how the web is changing the world". The research described in this paper was part of our attempt to answer the questions "why are we doing this?" and "why would the learners want to study MOOCs?"

These questions are worthy of discussion at a time when the landscape for higher education is widely predicted to change, as the result of the disruption caused, mainly by the way the web is changing the world! Reports such as Barber et al., 2013 predict that business models for higher education are about to collapse in much the same way that the music industry's business model collapsed in the 2000's; and possibly MOOCs are the Napster in this scenario. These predictions are being followed by real financial investment: text book publishers are rapidly re-inventing themselves as purveyors of on-line education, and lobbying government for a level playing field with universities; and venture capitalists are lining up at universities' doors trying to buy into a share of their more popular courses. Venture capitalists expect quick profits, so they are presumably banking on rapid disruption. If MOOCs are at the frontier of such disruption, then what is the motivation for universities to embrace them rather than resist them?

In 2013 many universities, for example in the in the UK FutureLearn Consortium, have been investing greater sums of money in developing single MOOCs (sums of £30K - £60K are regularly quoted) than they have been accustomed to investing in the development of much longer courses. It is relevant therefore to ask what is the business model for universities in making this investment.

When it comes to student motivation for learning, teachers in higher education have insisted for years that learning is driven by assessment (e.g. Boud, 1995), and yet learners are registering for MOOCs in an enormously wide range of subjects in their tens of thousands. Clearly they are not motivated by grades since in most MOOCs there are no grades. So it is valid to ask why these students are so interested in studying MOOCs.

In carrying out our research on student motivation we wished to get beyond the survey of the set of students that completed a particular MOOC and to investigate some of the cultural differences in motivations, so our results are based on a survey circulated by social media within the UK, Spain and Syria.

2 METHODOLOGY

As indicated above, our research is divided into two studies, looking at

1) Higher Education Institutions' (HEI's) motivations to create MOOCs.
2) Learners' motivations for participation

The two studies use different methodologies. Our research on the motivations for universities was carried out mainly as a meta-review of the literature, but is also informed by our experiences and discussions with FutureLearn partners.

For learners' motivations an online survey was conducted to gather information about those who had participated in a MOOC, looking in depth into the reasons why learners decided to register and eliciting some reflections on their beliefs, attitudes and behaviours when participating in a MOOC. The questionnaire was analysed primarily by using a quantitative method of frequencies of responses.

It might have been good to have surveyed a number of HEIs about their motivations, but at present this is a very competitive arena, and it would be difficult to ensure the veracity or completeness f the responses that might be received. It is likely that this situation will change as the subject matures.

2.1 Methodology: HEIs' Motivations

For HEIs' motivations a qualitative approach using content analysis was conducted across a set of around 60 articles to evaluate arguments about whether or not HEIs should foster MOOCs.

2012 was really the year in which many MOOCs became available, mostly through Coursera, edX and Udacity in the USA. These MOOCs have now been evaluated and we are now beginning to see many papers published, but at the time we began this research there were few academic articles and to track the emerging phenomena of MOOCs it was necessary to also observe the web-based grey literature of journalistic articles, blogs and social media.

2.1.1 Identification and Selection of Sources

Selected contributions published in three different domains, were used: namely education technology journals; HE magazines; and blog posts. The sources were identified by using different search strategies depending on the domain where the literature was published. For the peer-reviewed academic literature in journals, the method used was inspired by the identification of sources in the systematic literature review by Liyanagunawardena et. al. of MOOCs carried out in 2013. The journalistic and blog (grey literature) sources were drawn from the curated collections of four educational technologists via the Scoop.it social media site over the four months prior to August 2013. These MOOC-focused curations drew on a wide range of sources of which a more reduced number were in turn chosen for this project, seeding by provenance and perceived authority and encompassing views which were either for or against the adoption of MOOCs in HEIs. Sources were primarily selected according to their relevance to the topic of MOOCs in HEIs.

- Academic literature was used to identify the drivers of the emergence of MOOCs
- Grey literature was used for identifying current debates.

More rigour and credibility was credited to peer-reviewed journal articles, than in journalistic pieces and blog posts. Therefore, the selection of the papers was focused on their content and relevance. The selection of grey literature placed greater emphasis on authorship and provenance because, as noted by Daniel (2012), the media contains abundant literature in which the intention of promoting MOOCs as products for profit seeking undermines the objectiveness of the judgements towards their potential to improve the education delivery.

2.1.2 Analysis of Sources

Herring's (2004) adaption of Krippendorf's (1980) Content Analysis (CA) method for online context was used with the academic and journalistic corpora of MOOC related sources. Apart from identification and selection of sources explained above, CA involves establishing of categories into which the arguments in the sources are to be distributed. With academic sources, MOOCs were placed into three contexts in order to explain their emergence. These contexts were

a) open education movements;
b) the evolution of technology in distance education;
c) disruptive innovations in education.

Because they were more opinion loaded, non-academic sources were classified into debates of sustainability, quality, and impact of MOOCs from an institutional perspective (for more information see León, 2013).

2.2 Methodology: Learners' Motivation

A MOOC heavily relies on the autonomy of the student to control their learning process. Termed "Self-regulated learning" (SRL), this concept which emerged in the 80s addresses the question of how students manage learning process, and includes cognitive strategies, metacognition and motivation (Zimmerman and Schunk, 2001). Motivation is an important part of SRL. Specifically, intrinsic motivation is needed to perform learning tasks as part of the forethought, the strategic process that precedes performance in learning (Barnard-Brak et al, 2010). Arguably, analysing the intrinsic and extrinsic motivation that leads a learner to take the decision to register in a MOOC is not easy, because there are many cognitive and affective components involved. However, it is more feasible to understand the reasons that may lead a person to consider undertaking a MOOC. The data was gathered through a questionnaire, from an empirical analytical perspective. The questionnaire contains 24 questions, grouped by the following themes:

About you. This section had the goal to obtain basic information about the participants: residence, age, gender, occupation, kind of learner.

Education. Focused on level of education and to know if parents attended University.

MOOC providers. To know if people had participated in any MOOC before, when it was, when and where they accessed to materials and what device they used for that.

Motivation. Related to know which MOOC platform have they used, how many MOOCs they have done, if they interacted with others, tools used in the MOOC experience, activities developed, and finally, questions related with reasons for starting a MOOC, and for abandoning it if that was the case.

The survey was designed and piloted. It was also translated into Arabic and Spanish, to obtain data from those language environments. The questionnaire was published using the University of Southampton web based survey tool iSurvey. The responses to questionnaire were elicited through Facebook, Twitter and email. Once the data was collected, it was analysed through SPSS software. The categorising and coding process of the variables for the questionnaire was related to the type of question (mainly nominal) and a direct reading of the data was made by frequency calculation.

3 FINDINGS: MOTIVATIONS FOR HEIS

3.1 MOOCs in Context

The analysis of the two sets of sources generated a number of observations on the institutional motivations and reactions to MOOCs.

The main observations In terms of the established contexts of the emergence of MOOCs determined by the analysis of academic sources, were as follow:

Strategic Growth: Marshall, 2013, argues that developing MOOCs is part of HEI strategic plans to remain competitive in the market for learners seeking and affordable education balancing the 'bargaining power of buyers' and the 'bargaining power of [competitor HEI] suppliers'.

Marketing: Delarocas & Alstyne, 2013 observe that MOOCs are often introductory courses which contribute to a recruitment marketing strategy aim to reach large numbers of MOOC learners as a means of targeting potential paying students

Strategic Collaboration: Universities are gathering in consortia around emerging MOOC platforms, such as Coursera and FutureLearn and EdX. The University of Edinburgh's report 2013 identified belonging to peer communities as a way to explore new educational methods, and secure greater reach and more presence for their courses.

Organic Growth / Evolution: Yuan & Powell, 2013 argue that MOOCs emerge as a natural evolution of Open Educational Resources (OERs). HEIs especially those already championing OERs, such as Harvard and MIT are compelled to sustain Open Education within this new format.

Response to Learners: Castells influential 2011 analyses contemporary societies' emphasises use of available technologies to engage in networked interactions, in the 'networked society'. Williams et. al., 2012 observe that learners are not only ready to learn collaboratively through social media but also demand it. This trend has permeated the education domain, and leading HEIs must develop pedagogical approaches that fulfil these demands if they want to maintain their top positions in the rankings.

Learner Analytics: MOOCs produce large quantities of learner data. This is valuable data that can inform the design of enhanced, customised and effective instructional methods, which may in turn raise the perceived quality of tuition in universities, and hence improve competitiveness. Analysing these datasets can shed light on collective and individual learning processes and patterns (De Liddo et. al.

2011), learners' engagement levels in different course stages (Breslow et al, 2013), or their potential for success or failure (Barber and Sharkey 2012).

Educational Enhancement: taken collectively the observations above also suggest that educational enhancement is either a sub-objective or a happy consequence of MOOC participation.

3.2 Main Debates on MOOCs

An extensive survey on the contemporary grey literature identified three areas of sustainability, quality, and impact in which the debates were more frequent and intense. Within sustainability two main themes occupied most of the debates, 1) analogies with other business initiatives; 2) learners' sustained participation.

The business analogy of sustainability championed by Marginson (2012), Young (2012), and the Economist (2013) draws parallels between MOOCs and successful business models of Silicon Valley initiatives such as Google and eBay, who made early investments, provided free services, and now make substantial profit. Weston, 2012 presents another side of the debate citing the experience of companies who suffered the dotcom bubble; Ptascynsky, 2013 suggests that universities will realise that they do not external platforms to run MOOCs, since universities can provide fairly feasible technological solutions without the need of third parties.

The sustainability of learners' participation, debate has optimist commentators such as Lawton & Katsomitros, 2013 arguing that high numbers of enrolling students provide an opportunity for novel sustainable business models whereby some costs are met by institutions, governments and future employers while students pay for assessment and certification.

However, the interpretation of the high drop-out rates is contentious and relate to the quality of provision as well as sustainability. Sceptics like Tauber, 2013 see them as a serious issue rooted in a poor conceptualisation and design. Kollowitch 2013; 2013a illustrates the failure of MOOC models with concrete examples, such as the bad experiences with MOOCs of Colorado State University and San Jose State University. However Catropa, 2013 counters this sceptical view as a mistake of underestimating the high number of students who actually complete a MOOC despite the high drop-out rates and Parr, 2013 claims it ignores the fact that many learners who do not complete a MOOC still benefit from it.

There were frequent debates in the media regarding the quality of MOOCs. Sceptics see them as not being able to reproduce the discussions that takes place in small face-to-face group settings, which are deemed as the only way meaningful learning can take place (Rheingold, 2013; Brighouse, 2013). A frequent counterargument is that seminar discussions can and have been reproduced successfully in web-based experiences (Davidson, 2013). Also, many recognise that MOOC tuition quality might be lower due to the ratio of students to teacher, but it is still reasonable for those who will otherwise not access HE (Horn, 2013).

A further motivational factor to HEI involvement in MOOCs is their impact and spread. Lewin, 2012 compares it with a tsunami; the more universities join the movement, the more universities will be urged to join it. This tsunami will fuel a revolution in HE. However, sceptical views, such as that of Drezzner (2013), situate the current enthusiasm in the beginning of a hype cycle that will soon deflate.

3.3 MOOCs as Distance Education

The literature identifies six distinct generations of distance education associated with the role of technology in each step: (Nipper, 1989, Taylor, 1995, 2001; Fozdar and Kumar, 2007; Caladine, 2008) MOOCs can be considered alongside this timeline.

First Generation: a "correspondence model", studying via mail.

Second generation: incorporated technologies such as video.

Third Generation: combining tools and telecommunications (Nipper, 1989), also referred to as "telelearning", e.g. incorporating the use of videoconferencing. It is also the moment when educational concepts as "open education" and "flexible learning" emerge

Fourth Generation: "the flexible learning model" Taylor (1995) emphasises the use of technology and the Internet in the 90s from different Universities, with the first eLearning experiences.

Fifth Generation: adds the emergence of Virtual Learning Environments (VLE), the use of Virtual Campus and resources processes characterized by automation systems (Taylor, 2001).

Sixth Generation: based on Web 2.0, like a model of progress of interactive environments. (Caladine, 2008). Blogs, wikis and social networks have changed the way people use the Internet, and represent new opportunities to learn.

Perhaps MOOCs will become the seventh

generation in distance education. Clearly they enact a model of distance education. The current "boom" in the university narrative created by MOOCs suggest some turning point in distance education. Although perhaps in terms of a formalized educational understanding of MOOCs it is rather early to make that claim.

3.4 Structure and Assessment in MOOCs

Two distinct kinds of MOOC are widely recognised: xMOOCs and cMOOCs. The xMOOCs focus on course content and are typically located on a single web platform which provides access to the contents. cMOOCs are related to connectivistm incorporating the design and realisation of networked learning and based on the ideas of Siemens (2012a, 2012b) They start from the idea that we learn when we connect with other people, accordingly cMOOCs manifest in a more open format working with social and collaborative tools.

In early MOOCs, the opportunity provided by participating in a MOOC was not to primarily obtain a certificate, but to learn. This aspect of cMOOCs is highlighted because "participation in a MOOC is emergent, fragmented, diffuse, and diverse. There is no credit or certificate offered for completion" (McAuley et al., 2010).

More recently, many MOOCs, particularly, xMOOCs, offer certification (free or charged), providing participants the chance to formally record their learning and thereby to improve their CV. O'Toole, 2013, in a discussion paper looking at peer assessment, asserts that "whereas in the cMOOC participants are primarily interested in building the collective capabilities of the whole network, and hence are more likely to use feedback and ratings systems honestly, in xMOOCs participants are aiming to get a good personal grade". A demand for validated certification exists and some companies are beginning to sign agreements with institutions to provide MOOC participants with such services e.g. the agreement between Udacity and Pearson to create a network of assessment centres, and a similar agreement between Miriadax, the Spanish MOOC platform and Telefonica.

4 FINDINGS: MOTIVATIONS OF LEARNERS

4.1 Findings

A total of 258 questionnaires were completed: 52 English, 193 Arabic, 40 Spanish. The majority of respondents were in the 18-24 age range there are variations depending on the survey language identified throughout the survey. Male respondents formed the majority (72.5%). We note that this sample may not be typical of the MOOC learner community as it has so far emerged in the USA and UK, where typical figures indicate roughly equal participation across the age range and genders. We assume that the method of distributing the survey may have had an effect.

Table 1: The majority of respondents were male.

English	67.3% male
Arabic	77.2% male
Spanish	48.7% male

When participants were asked about the platform, figure 1, Coursera leads by far over other platforms. However, this percentage is higher in the English questionnaire than in the rest. It is important to note that close to the 25% of those who answered the questionnaire in Spanish identified a platform tailored to Spanish language MOOCs called Miriadax, Similarly Arabic respondents indicated a range of other platforms, such as the Virtual Syrian University. (Note that at the time of this survey, FutureLearn had not yet launched).

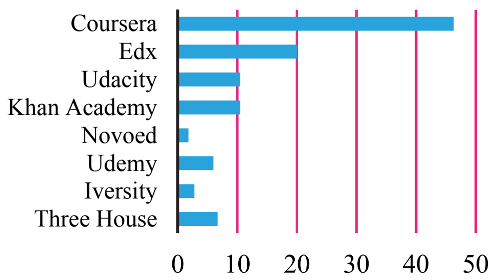

Figure 1: MOOC platform used.

A large volume of interesting data have been obtained from this questionnaire, however, the remainder of this paper will focus on motivation related data, concentrating on reasons that that led respondents to participate in a MOOC. In this section, respondents could choose from a number of options and could check more than one. Carefully analysing these data, a number of reasons normally found in the web and scientific discussions, appear to be confirmed. Figure 2 shows all options:

The following analysis explores the findings, indicating whether or not they underpin, widely perceived motivations behind learners on MOOCs.

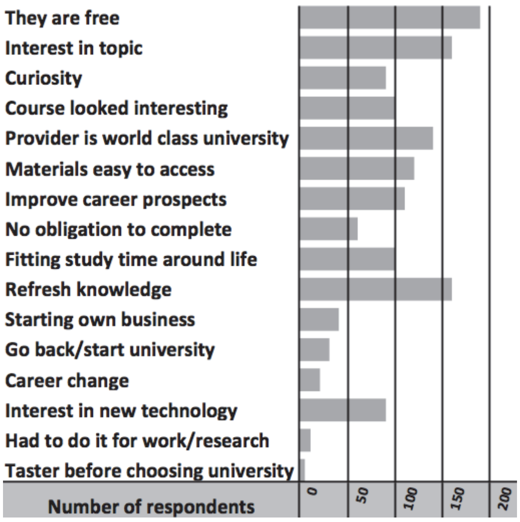

Figure 2: Distribution of responses about motivation.

4.1.1 MOOCs are Free and Open

Free availability is the important factor according to the survey selected by 67%. A particularly high number of respondents from the Spanish questionnaire selected this option (72.5%).

Providing educational resources for free is not a new and open licensing for software, resources and learning objects is well established. MIT launched the Open Course Ware project (OCW), in 2001 to share web-based teaching materials under Creative Commons licenses. The main difference between MOOCs and OCW is that while initiatives like OCW focus on sharing teaching materials, Universities are using MOOCs to realise a complete learning process. Learners are not only able to access the material, but they can also follow lessons, develop activities, talk with online-classmates, and even be evaluated, all for free and usually open.

If freeness is a fundamental aspect that motivates students to follow a MOOC, and it would be interesting to know which aspect of this is most relevant to them.

4.1.2 MOOCs are Convenient: Fitting around Life

There are clear differences in motivation related to fitting study time around your life, in general, this selection is not chosen by a lot of people (36%), but it is of interest. The Arabic responses show 27.5% interested in this aspect, the Spanish represents 65%. The majority of Spanish participants were in full time employment which may be the reason that they rate this aspect as relevant.

4.1.3 MOOCs Update Knowledge and Improve CVs

The question **A MOOC helps to improve a CV**: appears more related to the need for certification to be shown in a CV. In the survey, improving CV was selected by 54.4% of all participants as one reason to use the knowledge in a MOOC, but this percentage rose to 61.7% of Arabic participants, probably because the majority were students. This is consistent with other studies, for example in the study by Duke University (Belanger & Thornton, 2013 this is been highlighted as the main reason students participated. **A MOOC helps to update knowledge:** has been highlighted by many as very relevant and motivation. Specifically 59.1% of Arabic and 70% of Spanish participants said that one main reason to do a MOOC is to refresh knowledge.

4.1.4 MOOCs Build a Social Learning Community

MOOCs may have social components that motivate learners to register to participate. Some 55.8% of respondents affirmed they were the first among acquaintances, family, colleagues and friends to participate in a MOOC. However 124 respondents from 285 found out about MOOCs via social media and then decided to participate. MOOCs can represent an opportunity for socialization. Online community has become increasingly important in the Internet user's life. Web 2.0 tools (blogs, wikis, social networks) make the Web as a place to develop social community where participation is important.

4.1.5 MOOCs Satisfy Interest and Are Useful

In a market with a lot of options, MOOCs can represent a new way to learn and access to interesting digital content. Interest in the topic is one important reason for participating in a MOOC, 56.8% overall. English respondents showed the highest preference with 80% of English respondents selecting this aspect.

Usefulness also features; 60.6% of participants overall declared they would use the knowledge gained during the MOOC in a personal project, and 63.2% in personal development These data follow the same line as other research, such as Duke University, in North Carolina, USA, which found that interest in the topic was identified by 87% of the students as a motivational aspect (Belanger & Thornton, 2013). In this same study, many students indicated that they thought the course would be fun and enjoyable. This aspect of 'edutainment' where usefulness and fun intersect may be of real importance.

4.1.6 MOOCs Enable Learning with the Best

The origin of MOOCs in prestigious Universities, or by the effort of high profile or world leading academics may explain their apparent popularity and rapid growth and their power to attract the attention to many different learners. Although not quite the majority, about half the respondents, 48.1%, identified 'provider was a word class university' as a reason for participation. The power of some Universities is apparent. There is some difference by origin of respondents. English respondents show the least interest at 38.5%; Spanish 43%; Arabic 51.8%.

4.1.7 MOOCs Provide Professional Development and Lifelong Learning

The University of Edinburgh report summarising of the experience of their six Coursera MOOCs in May, 2013 observed "In general, we attracted adults with high educational attainments". That is reflected in the survey 208 of the 282 have a degree (mainly undergraduate 133 of 285. There are more post-doctorate learners in English and Spanish than in Arabic respondents.

The largest represented age range (50,5%), is between 18 and 24 but there are a lot of differences depending on the scope: most Arabic users are in the range of 18-24 years old, this percentage decreases in English and even more so in the Spanish results, in where the largest represented age range is the 25-34 years old.

Motivations for 18 to 34 years may be closely related to the opportunity to improve their career, and moreover, enhance their professional network. Half the respondents indicated that participating in a MOOC enabled them to enhance their professional development and improve their knowledge in the workplace. Among Spanish participants the percentage identifying this as an important factor rises to 77.5%

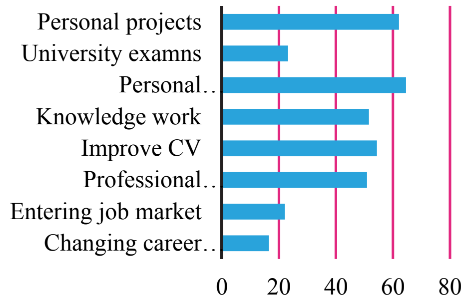

Figure 3: How will you use the knowledge gained during your MOOC.

The survey asked how respondents would use the knowledge gained in the MOOC (figure 3). The most widely identified factors were personal development and projects. In a world increasingly multidimensional and diverse, MOOCs can work in Universities as a piece of the system providing open learning opportunities forming part of the learner's personal learning network. Professional and personal development needs are increasing alongside rapid business change. Therefore, MOOCs can offer a learning opportunity for people to develop life long learning.

5 ISSUES

5.1 Pedagogic Possibilities or Illusion?

The UK Department for Business, Innovation and Skills published a report in September 2013 reviewing the MOOC literature. They identified two trends in educational press, blogs and general media. One enthusiastically promoting MOOCs and reporting positively on learning experience and innovative forms of pedagogy, focusing on concepts like collaboration and community. A second sceptical view focussed on two fundamental flaws: the supposed benefits of MOOCs are the victory of content packaging; and the MOOC format itself is exclusive and does not have enough quality to develop skills in learners.

Educational technologists have spent years arguing that learning online is not only about content. In 1995 Bates suggested that open and flexible education should consist of the provision of flexible learning, built around geographical, social, and time constraints of each student, instead of being built around educational institutions' needs. The opportunity offered by the Internet for teaching and learning is change enable learning opportunities within flexible models, How can a MOOC, developed for hundreds or thousands of students, meet these aspirations? Educationally, MOOCs are only a small part of the multiplicity of wider international University systems. They cannot be assumed to be the panacea that will solve all educational problems.

Moreover, the very high drop out rate behind MOOCs is widely recognised. Clow et al. (2013) categorise that phenomena as “the funnel of participation”. The funnel consists of four stages of participation: awareness; registration; activity and progress. What is not know is the extent of the participants satisfaction with the their (perhaps very limited) participation. However, “bad experiences” with MOOCs have been reported. In July 2013 “Inside Higher Ed” reported that, after six months of high-profile experimentation, San Jose State University plans to “pause” its work with Udacity, because “preliminary findings from the spring semester suggest students [in online joint Udacity/San Jose courses] do not fare as well as students who attended normal classes”.

5.2 Assuring Assessment for Learning

The volume of learners in MOOCs perhaps inevitable makes feedback and the assessment two highly debated aspects MOOCs. In general, before MOOCs, assessment in learning online was a challenge for educators, mainly because it is an area that has seen little change. MOOCs are demonstrations of assessment online and at scale. Since technologies allow focus upon and tracking of the student learning process, e-assessment need not be an action that occurs only at the end of the course. However, taking into consideration skills and other aspects of the learning process, there is a lack of systems that facilitate a complete assessment, (Strither, 2002; Driscoll, 2007; Radenkovic et al, 2010).

Another desirable and thus important aspect of the learning process is feedback, assessment for learning. Feedback on assessment online is not always integrated in the mechanisms that assess students. It is challenging in a MOOC environment to develop effective assessments where, feedback reinforces learning and identifies inconsistencies in the learner process,.

Additionally, the “massive” (independent and remote) nature inherent to MOOCs, makes it more difficult to develop high quality assessment. Although some MOOCs incorporate “peer assessment”, O´Toole (2013) notes that, rather than peer assessment, it should be called “peer-grading”, since it cannot be assumed that an equal or adequate level of understanding about assessment is possessed by all MOOC learners.

5.3 Costs – Benefit or Risk?

MOOCs are in principle free for students, although some platforms now incorporate a fee for a certificate of participation. MOOCs are not free for institutions. Universities have to invest time and money designing and uploading materials, managing the course, providing feedback. It is not clear if this model is sustainable over the time.

Luján (2012) discusses an interesting perspective that the most important American universities may be using MOOCs to protect themselves against a possible outbreak of "the bubble of Universities". This stresses the hypothesis that a MOOC can work for universities as an initiative to contain costs and enrol more students, thus obtaining more revenue and helping to resolve the crisis in the sector

Yuan and Powell (2013) suggest that companies may want to invest in MOOCs in order to enhance the company brand or a route to a new income stream from Higher Education business. Such motives may lie behind some companies signing agreements with institutions to provide services to MOOCs, such as the contract between Pearson and Udacity to create a network of evaluation centres.

5.4 Widening Inequalities

MOOCs can create inequalities at different levels: among students, across educators, between institutions, and even at a global level. Regarding students, Cookson (2013) points out that job seekers with MOOC certificates will pose weak competition to those with traditional degrees. Carlson & Blumerstyk (2013) note that the skills needed in a tertiary sector driven economy such as talking in public or business etiquette can only be acquired through face-to-face tuition. Those who most need these skills are the most disadvantaged, mainly due to their social backgrounds, and MOOCs may not be able to empower them.

Educators can also face inequalities following a massive adoption of MOOCs. While scalability could allow an elite of ‘superstar’ professors reaching massive audiences, it may leave the rest of educators in precarious conditions (Engler, 2013).

At institutional level, universities that can afford the costs of engaging in MOOCs may leave competitor institutions with little market share, as massive uptake could lead to centralisation.

Although widely contested, Sebastian Thrun's prediction that only a few universities would be needed in the world (Leckart, 2012) should not perhaps be taken lightly.

Finally, at a global level, Sloep (2013) explains that, far from promoting inclusion, MOOCs promote cultural imperialism, because "developing countries lack the financial and human resources to develop an educational system of high quality, so when they confronted with MOOCs they cannot afford the luxury of refusing them".

5.5 Learners' Digital Competencies

From the first reports about MOOCs (Group MOOC, 2013; Osvaldo, 2013) a clear profile of learners that participate in MOOCs emerges; postgraduates and professionals. Brown (2013) points out that perhaps others e.g. undergraduate students are unlikely to possess the skills needed to be an autonomous learner in a MOOC.

Although such skills may be a prerequisite to effectively participating in MOOCs a wide range of people that do not have such skills can and do enrol. It would be interesting to investigate if the dropout found in MOOCs could be in part explained for the fact that there are people who register but they feel later they are not able to follow it for lack of skills.

5.6 Certification to Overcome Plagiarism?

Plagiarism is another issue to be borne in mind for a number of reasons. Firstly, if certification and accreditation are to become a significant part of the MOOC business models, the certificates issued by HEIs need a credibility that might be undermined by potential academic integrity breaches easily achieved from the anonymity of the web.

Also, the concept of plagiarism is not the same in all cultures. As Wilkinson notes (2008) students in certain Asian countries do not see plagiarism as an academic integrity breach, but as a way to show respect to the authority of the content producer. Therefore, universities not only should incorporate plagiarism detection software in their MOOCs, but also emphasize and clarify the principles of academic integrity expected in their programmes.

6 SUMMARY AND DISCUSSION

This paper has examined the motivations of institutions for making MOOCs and the motivations of learners for registering and completing them. It is clear that these are not simple matters so it is not surprising that there are no simple answers. However there are some useful understandings that we gained from our studies, surveys and interactions with other MOOCers that should be borne in mind when considering motivations.

When it comes to considering institutions' motivations to produce MOOCs, we need to understand that institutions are very much aware of predictions for the way the learning landscape will change with the disruption caused by on–line learning; forward thinking institutions believe that they need to be agile and respond to these changes.

Creating MOOCs can be seen as a way of enhancing the institution's reputation, not only in the subject area of the MOOC, but also in the area of quality on-line learning. Furthermore, internally, in the university, the enthusiasm and skills that go into producing MOOCs are the same that are needed to grow internal capacity for engaging with and producing quality on-line learning courses.

In the near future we may expect to see much softer dividing lines between accredited courses and MOOCs, on-campus education and off-campus education as universities start to make use of their MOOC materials to add value to their accredited courses, and in the extreme to produce whole programmes based on MOOC materials, as we starting to see with, for example, the Georgia Tech Computer Science MSc.

From the point of view of learners there would appear to be two important groups – those that see doing MOOCs as a form of Edutainment; perhaps an alternative to TV for the more discerning adult while another group are those that are seeking educational improvement for the sake of improving their career and life prospects.

MOOCs come in for much criticism for the high drop out rates, with only a small percentage of starters completing the course. But we need to be aware that the motivations of those who register for MOOCs are diverse and may be very different from those who register for University programmes. For a start, many who register may have no intention of finishing – they are equivalent to forum 'lurkers' those who just want to have a look inside the course, and the only way to do this is often to register. Secondly, the many users who sign up motivated by the edutainment will have a very different attitude to perseverance if the course turns out to be less interesting, more time consuming or harder than they had expected, than if they were signed up, at a personal cost, to a course that they believed to be critical to their future.

Finally, we should not assume that all learners intended to complete the whole course. Many learners may only be interested in part of the course, or may have time constraints that they knew when they started that would not enable them to complete the course. Nevertheless, since MOOCs are free and there is no penalty for failure to complete, many learners are enabled to drop in (and out) of courses at their own convenience. This should be a cause for educational celebration rather than criticism and represents learner choice and independence.

The authors are currently conducting further research jointly with the UK Higher Education Academy (HEA) attempting to identify the different behaviours and patterns that emerge from the range of motivations that learners express.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the work and enthusiasm of Olja Rastic Dulborough and Maraim Masoud two students who worked on internships in the Centre for Innovation in Technologies and Education (CITE) for the summer vacation of 2013. We would also like to acknowledge the respondents who freely gave time to reply to our survey.

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Motivation for Learning
Adaptive Gamification for Web-based Learning Environments

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Keywords: Gamification, Adaptation, Learning Environment, Motivation, User Model.

Abstract: Many learning environments are deserted by the learners, even if they are effective in supporting learning. Gamification is becoming a popular way to motivate users and enhance their participation on web-based activities, by adding game elements to the learning environment. But it still pays little attention to the individual differences among learners' preferences as players. This paper presents a generic and adaptive gamification system that can be plugged on various learning environments. This system can be automatically personalised, based on an analysis of the interaction traces. We first present the architecture of the proposed system to support the genericity of the game elements. Then, we describe the user model supporting the adaptivity of the game elements.

1 INTRODUCTION TO GAMIFICATION IN LEARNING

Many learning environments have been shown to be effective when used, but are quickly deserted by most of the learners because of a lack of motivation. Gamification is becoming a popular way to motivate user participation on web based activities. "*When done well, gamification helps align our interests with the intrinsic motivation of our players*" (Zichermann et al., 2011). Although this concept is not new (Deterding et al., 2011), yet little research treats its uses in learning contexts. This paper proposes a generic and personalised gamification system to raise motivation in learning environments that are not intrinsically motivating.

1.1 The Need for Genericity

Turning a learning environment into a game is a complex process. Currently, if the designers of a learning environment are interested in gamifying it, they have to re-design and re-implement the game elements especially for this environment. This could be very complex and require a lot of time, whereas the elements will not be reusable. The existence of generic game elements would address this problem.

Achievements systems like Mozilla OpenBadges (Mozilla, 2011) address this need for genericity, but using badges only is a poor way to gamify. Maciuszek et al. (2010) used a component-based framework for implementing educational games. It allows turning a learning software into a learning game by changing only the user interface components. However, the initial software needs to be already compatible with this framework in order to be turned into a game, which is not the case with most existing learning environments.

Thus, we aim to develop gamification as an independent layer that could be plugged on learning environments without changing them.

1.2 The Need for Adaptivity

When trying to motivate with games, an important difficulty comes from the fact that people do not have the same expectations, and do not have the same emotional responses to game mechanics (Yee, 2006). A common approach to fulfil these expectations is to add gamification features for all the player types within the application, but there is a high risk of overloading the user interface. That is why gamification needs to be personalised. Various researches contributed to the field of adaptive games, by adapting the user interface, the level of difficulty (Andrade et al., 2006), the pedagogical scenario (Marne et al., 2013), or the feedback (Conati et al., 2009). We aim at developing an adaptive motivational system addressing the three deficiencies highlighted below.

The first lack identified in existing works is about games genre and dynamics. Game dynamics are defined by Zicherman et al. (2011) as "*the player's interactions with the game mechanics*". Related works in adaptive games share the goal of increasing the game's acceptance and usability, but the game dynamics remains the same.

The second lack concerns the adaptation of gamification. While many works focus on the adaptation of games, few are interested in the adaptation of gamification. Ferro et al. (2013) are among the first researchers to conduct works on personalised gamification. They are trying to relate directly game mechanics and game elements to both player types and personality types.

The third lack concerns research on adaptation of multi-player games. It has been shown in the game adaptation techniques review of Hocine *et al.* (2011). As gamification mainly relies on competitive and social features, it is important to consider ways to apply it for groups of users.

1.3 Main Research Questions

Our research works aim at developing a motivating system, adaptive and adaptable to various web-based learning activities.

The main research questions related to this goal are: (1) How to characterise the game elements to make them generic and pluggable to the learning environment? (2) Which user model can handle the adaptivity of the game elements? (3) Which architecture can support the tracking, the adaption, and the integration of the game elements?

Section 2 is dedicated to the state of the art related to gamification and game elements. Then in section 3 we present the overall architecture of the system to make gamification generic. In section 4 we provide details about our user model to make gamification adaptive. We finally conclude about the contribution of the paper and present future works in sections 5 and 6.

2 STATE OF THE ART

2.1 Serious Game or Gamification

Games and fun have proven to enhance motivation in learning activities. But various approaches are used to add fun in different cases. The most popular ones are learning games and gamification. Learning games refer to the use of digital games for learning purposes (Prensky, 2001). Gamification has been defined more recently as "*the use of game design elements in non-gaming contexts*" (Deterding et al., 2011). These two approaches are often poorly distinguished one from the other. However, they differ by their design process and by the resulting application (see Table 1).

Table 1: Differences between a learning game and a gamified application.

	Learning game	Gamified application
Design process	Designed as a game from the beginning	Adding game mechanics to an existing application
Resulting application	A game with educational elements	A learning application enriched by game mechanics

In this work, we focus on gamification. On the one hand, it can be based on existing learning environments. On the other hand, with gamification the game elements are not central but peripheral, which fosters their adaptivity. Thus gamification can become a "fun layer" that could be plugged on several applications (Monterrat et al., 2013).

2.2 User Model and Adaptation

2.2.1 Distinguishing Learner and Player

In the game-based learning field, user adaptation can focus on the user as a learner, or as a player, because each user is both of them. Research on learner model focus on the relation between the learner and the knowledge. For example, the theory of adaptive hypermedia (Brusilovsky, 2001) tends to adapt the content of the user's learning activity.

In our work, the role of user modelling is to adapt the game elements of the gamification layer. Accordingly, we assume that the learner part of the user model is handled by the existing learning application core that manages the learning activity, while the gamification system focuses on the player part. That is why we are particularly interested in player model in next part.

2.2.2 Player Models

Many studies have been conducted about why people play games. For example, Bartle (1996) identifies four player types: killer, achiever, socialiser, and explorer. Yee (2006) identifies three main motivation components: achievement, social and immersion. Lazzaro (2004) observes four motivational factors for playing games: hard fun, easy fun, altered state and people factor. Moreover, with the growing interest for gamification since a few years, various companies and game designers propose their own types of gamers (Kotaku, 2012, Gamification Co, 2013). In this work, we rely on the classification of Ferro et al. (2013): dominant, objectivist, humanist, inquisitive, and creative. Although their proposal is still a work in progress, this classification has the advantage to relate the player types directly to game mechanics and game elements. This link allows us to personalise and adapt our system to the players (see section 4.2).

2.2.3 Adaptation Techniques

Many different adaptation techniques can be found in the state of the art. They are based on various AI methods, as for instance: reinforcement learning to build intelligent adaptive agents (Andrade et al., 2006), Case-Based Reasoning (CBR), Bayesian network to build a student model (Conati et al., 2009), and evolutionary algorithm to design the tracks of a car racing game (Togelius et al, 2007). This kind of algorithm could be useful to build more accurate user models. In this work, we chose to use adaptation rules written by humans in the first place.

2.3 Data for Game Adaptation

According to Kobsa (2001), we distinguish three forms of adaptation: to user data, to usage data and to environment data. All these parameter are important for the game elements personalisation.

2.3.1 User Data

We should pay attention to basic data about users, like their age and gender, as it has an influence on their levels of attention and motivation. Charlier et al. (2012) focused on the influence of the player's age. They argue that older adults need games without pressing time constraints. There are also gender differences in motivations for playing games. For example, Eglesz et al. (2005) found that women prefer Role Playing Games (RPG) while men prefer action, adventure simulation and sport games.

2.3.2 Usage Data

Most works presented in the review of Hocine *et al.* (2011) base their adaptation mainly on the data from user's interactions with the system. It is not a surprise, as this data is generally available without asking questions to the user. These interactions are the basic information used to fill the user model, which may contain the users' emotional state (Poel et al., 2004), their way of learning (Bernardini et al., 2010), their level of success (Andrade et al., 2006), their level of satisfaction, attention, and engagement. As increasing engagement is our goal in this work, it is also a variable we need to track.

The methods for measuring engagement can be based on humans (De Vicente et al., 2002) (observation or self-report), hardware (e.g. eye tracking) or software. The last one is the only one that we can automate in web based applications. (Bouvier et al., 2013) defines a typology of engaged behaviours, to determine if a player is engaged or not, but the interactions tracked are specific to games. Mattheiss et al., (2010) present a list of specific actions that can predict engagement or disengagement in educational computer games. For example, if the learner asks immediately for help without even reading the question, s/he probably does not want to spend much effort. Cocea (2006) also proposed useful examples of behaviors predicting user disengagement, but her approach is qualitative. In this work, we rely particularly on the quantitative and computable method proposed by Beck (2005), called *engagement tracing*.

2.3.3 Environment Data

Kobsa distinguishes the software environment (e.g. the browser), the hardware environment (e.g. the device), and the information about the place (e.g location and objects in the immediate environment). It is generally harder to get information from the third category, but recent technologies like mobile devices localization can help.

In this work, we are interested in knowing the human context, because people do not play the same way if they are alone, with friends, or colleges. For example, (Cheng et al., 2011) tried to find the good moments to play at work, while some works focus on the uses of games in the classroom (Sanchez, 2011). It is also important for us to know the device used and the learning context, as some ways of gamifying can be relevant only in some cases.

3 ARCHITECTURE FOR GENERIC GAMIFICATION

In this part, we explain how we design game elements to be generic, adaptable, and pluggable on already existing learning environments.

3.1 Game Elements as Epiphytes

In order to personalise the fun features, the learning application needs to be able to work with or without these features. That is why we propose to use epiphytic functionalities: applications that are plugged in another application without being necessary. Giroux et al. (1995) define epiphytic systems as follows: (1) the epiphytic system cannot exist without a host, (2) the host can exist without the epiphyte, (3) the host and the epiphyte have independent existences, and (4) the epiphyte does not affect its host.

By implementing the fun functionalities like epiphytes, we can enable or disable them independently for each user, in order to adapt his/her interface without affecting the learning application. This is also a way to foster genericity. We provide below examples of such functionalities that can be activated:

- A leader board of fast learners for competitive users.
- Badges and cups for challenge.
- Ability to leave tips to other users.
- Ability to share scores and success on social networks.
- A chat feature for users interested in socializing.

As shown on Figure 1, the epiphytes (E1 and E2) are distributed in the user interface, but controlled only by the gamification layer, independently from the control of the pedagogical activity.

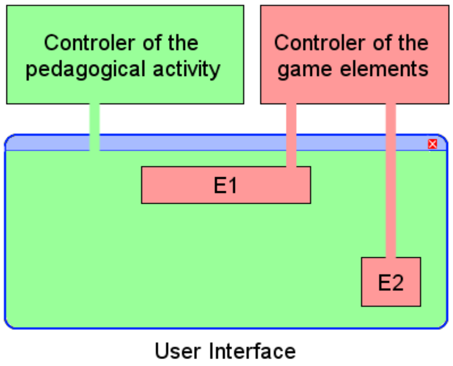

Figure 1: Independence of pedagogical control and game control.

3.2 Architecture

An overview of the proposed architecture is presented in Figure 2, which shows the way the gamification system can be plugged in an existing learning environment.

The interactions between the user and the environment are permanently traced (1) and stored in the database. Secondly, the data collected is used by the trace analysis system (2), which calculates frequently the engagement level of the user and stores it in the same base. When the trace analysis system detects user disengagement, it sends an alert to the adaptation engine before the user leaves. When the adaptation engine (3) receives an alert about the low engagement level, it updates the information of the player model in the same base, according to the history of engagement level and the use of activated epiphytes (see section 4.3.2), and selects the epiphytic functionality which best fits the user's needs. Finally, the selected functionality (4) is

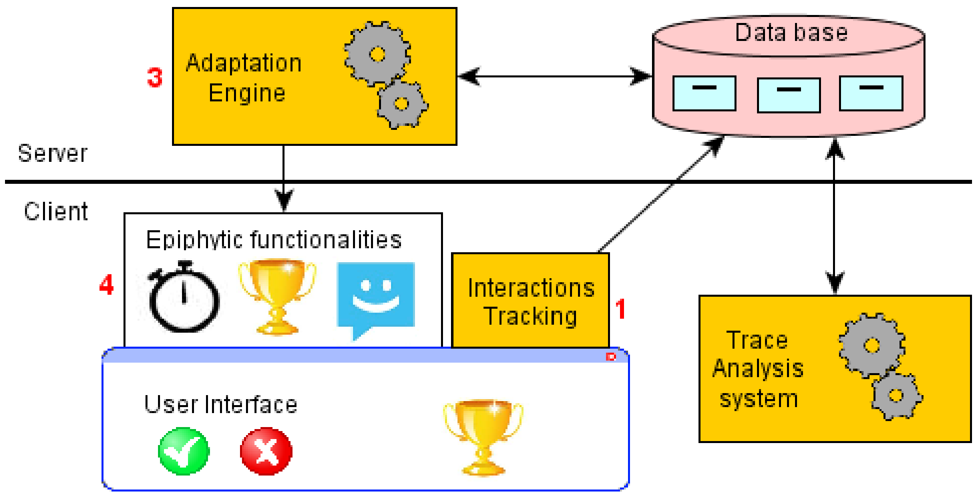

Figure 2: Architecture of the gamification system.

introduced in the learning environment (see section 3.3).

3.3 Integration of the Epiphytic Functionalities

There are different possible ways of introducing and integrating the functionalities.

On the one hand, the user needs to be aware of the introduction of a new functionality, so we have to inform him/her. On the other hand, the information must not interrupt the learning activity ("the epiphyte does not affect its host"), so a popup window is also not a good solution. As shown on Figure 3, we propose a small tooltip to inform the user without requiring any interaction.

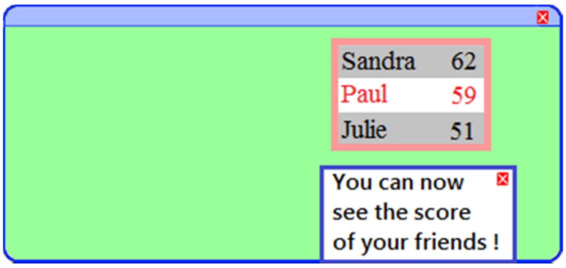

Figure 3: Tooltip to inform the user of changes.

The web technologies allow us to integrate the epiphytes in various ways on the web pages, like panels for the information displayed permanently, and tooltips for epiphytes based on punctual feedback. Examples are shown on Figure 4.

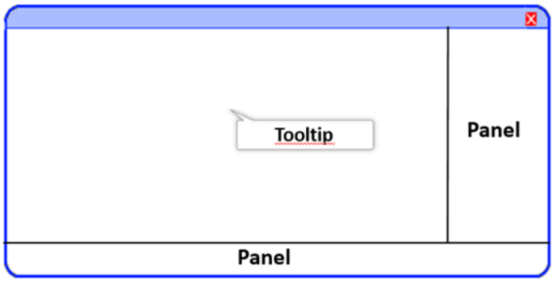

Figure 4: Examples of ways to integrate the epiphytic functionalities in a web user interface.

Finally, it is important to allow the users to disable the activated functionalities. The first reason is that some people do not want to play, and they should not be forced to, as games are a voluntary activity. The second reason is that the adaptation engine may be wrong during the first uses of the environment, and may propose a functionality that does not feet the player's preferences. Thus, the player can close the functionality. By the way this provides a useful feedback to the system about what the user does not like.

4 MODELS FOR ADAPTATION OF GAMIFICATION

In section 3.2, we presented the architecture of the system that supports a generic gamification. In this part, we focus on the adaptation process and the player model necessary for this adaptation.

4.1 User Model

An overview of the user model is shown on Figure 5, and its parts are details in the following subsections.

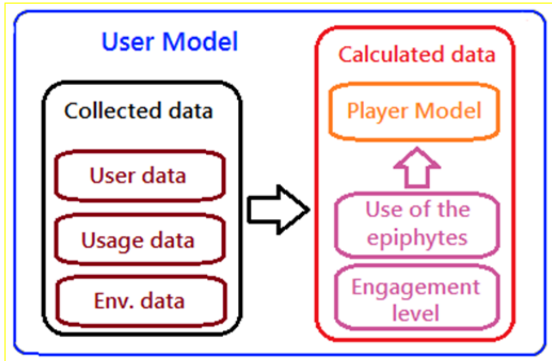

Figure 5: Overview of the collected and calculated data in the user model.

The data we want to know is registered within the player model (section 4.2), which tells us which game elements the user may like. It is calculated based on the engagement level, and the use of the epiphytes. The collected data is detailed in section 4.3)

4.2 Player Model for Adaptive Gamification

In section 2.2 we explained why we chose to base our model on the classification of Ferro *et al.* (2013). The list of its motivational factors is presented in Table 2.

Table 2: Player classification of Ferro.

Classification	*Examples of game elements*
Dominant	Characters, conflicts
Objectivist	Objectives, challenge
Humanist	Story/Narrative, dramatic art
Inquisitive	Aesthetics, boundaries
Creative	Resources, world building

When a new user registers on the learning environment, the values of each motivational factor are initialised for him/her according to user data (see section 4.3.1). During the use of the learning environment, the values will change according to the user's interactions (see section 4.3.2).

In addition, each epiphytic functionality also has a list of values associated with the motivational factors. Table 3 provides an example of such association.

Table 3: Example of values associating the epiphyte "leader board" to the motivational factors.

Leader board	
Dominant	100%
Objectivist	40%
Humanist	20%
Inquisitive	0%
Creative	0%

These values are necessary to choose the adequate functionality when we know the user's player profile.

4.3 Data for Gamification Adaptation

The three types of data we use for adaptation (Kobsa et al., 2001) are based on the state of the art presented in part 2.3.

4.3.1 User Data

The user data we use for adaptation are

- Birth date
- Gender

These data are static, but they have an influence on the initial values of the player model. Adaptation rules can be extracted from our knowledge on the influence of these data, and these adaptation rules can be used to set better values for the player model of new users (see Table 4 for examples).

Table 4: Examples of adaptation to user data.

Tom is a man. When he registers on the learning environment, his value for the motivational factor "competition" is set at 60%, instead of 40% for a woman	Nadia is 62 years old. When she registers on the learning environment, we set a limit of 2 epiphytes activated at the same time.

4.3.2 Usage Data

We need to track the user's interactions with both the gamification layer and the learning environment, to evaluate the level of engagement.

Concerning the tracking of the epiphytic functionalities, we can assume that the more a functionality is used, the more the player is sensitive to the motivational factor associated with this functionality.

Table 5: Examples of adaptation to the use of epiphytes.

Tom is now able to publish on a social network when he finished a learning session. He uses this functionality many times. Accordingly, his value for the motivational factor "social" increases.	The button for sharing activity on social networks has been introduced in Nadia's interface. She turned it off after one minute. Accordingly, her value for the motivational factor "social" decreases.

As some functionalities do not require direct interactions, the system has to find a correlation between the activation of the functionalities and the engagement of the learner. A functionality is effective if it is correlated with a high engagement.

Table 6: Examples of adaptation to the engagement level.

The leader board was added in Tom's environment, but no difference was observed in his behaviour. His value for the motivational factor "competition" decreases.	Since the leader board was added in Nadia's environment, she is connected more often and makes more exercises to raise her score. Her value for the motivational factor "competition" increases.

Our way of calculating engagement and disengagement is detailed in section 4.4.

4.3.3 Environment Data

In addition, some contextual information are crucial for the gamification engine. Firstly, it is useful to know if the learner is at school, at work, or on free time, as this context has an influence about how people learn.

We are also interested in the device used by the player. In the cloud computing domain, various learning environments are available on mobile devices as on computers, but all features are not necessary relevant or available on any device (e.g. because of the screen size).

Summary of the environment data for adaptation:

- Device used.
- Learning context (school, work or personal).
- Size of the group (if school or work).

Table 7: Examples of adaptation to environment data.

Tom learns at school in the computer room with his other classmates. Accordingly, a chat feature would be useless because he speaks directly with them.	Nadia, whose motivational factor "competition" is high, sometimes learns on her smartphone. Accordingly, we can propose her to compete with players locally near from her.

4.4 Engagement Tracking

We have access to one information directly indicating engagement:

- The session dates.

A user connected more often and longer can be considered as more engaged in the activity than another. However, this allows us to know the general engagement but not to compare the engagement level at two distinct times. That's why we need another way to track real time engagement. We use two metrics:

- Too short time to read texts and to answer questions, based on engagement tracing (Beck, 2005).
- Too long time to read or answer questions.

4.5 Adaptation Technique

The gamification engine has two roles: updating the player model and selecting a functionality adapted for the user.

To update the player model, a simple algorithm based on adaptation rules increases or decreases the values of the motivational factors, according to the observed use of the epiphytes and the engagement level (see section 4.3.2). Then, the engine has to select the motivational factor with the highest value, and to identify an epiphyte corresponding to this motivational factor, according to the association table (see Table 3). This behaviour must be balanced with some random selections. Selecting the functionality totally randomly would be ignoring the user model. But if there is no random, the functionalities implementing new motivational factors for this user will never be tried.

Finally, as the epiphytes may induce interactions between users, this engine has to "*take in account the collaborative aspect and heterogeneity between players, while maintaining the overall coherence of the game*" (Hocine et al., 2011). That is why the adaptation engine checks if several users of the group are interested in competing before activating multi-player functionalities.

5 CONCLUSION AND DISCUSSION

In this paper, we proposed the architecture of a system to motivate learners by integrating game elements in existing web-based learning environments. This system is both generic and adaptive.

The genericity is based on the use of game elements as epiphytic functionalities, which does not affect the host environment when integrated in the user interface.

The adaptivity is based on a player model that defines the player type matching best with the user. The adaptation process has four steps:

1. Tracing data from the learning environment and the game elements.
2. Evaluating the engagement level of the user.
3. Updating the player model, based on adaptation rules, using basic data about the user, data from the use of the environment, and data describing the learning context.
4. Integrating within the user interface the epiphyte matching best with the player model.

This system is not designed with the goal to turn every learning activity into a game, because games need to be played voluntary and people in some contexts are already motivated to learn. Adaptive gamification should be used with non-intrinsically motivating activities, like memorizing vocabulary or mathematical rules.

Despite this system has not been tested yet, it addresses three lacks in the literature and existing software:

- It proposes the adaptation of game dynamics, whereas existing systems (e.g Khan Academy, 2006) adapt the learning path and difficulty level.
- It deals with adaptation of gamification, whereas the literature deals more with adaptation of games.
- It proposes the adaptation of multiplayer features, whereas existing environments propose the same game elements for all the users.

6 FUTURE WORK

We plan various evaluations and improvements for the system.

Regarding the evaluations, we are currently implementing the system, which will be plugged on

"Projet Voltaire", a web-based environment to learn French spelling. For the next step, we will plug the gamification system on other learning environments, in order to evaluate its genericity.

An experiment will allow us to evaluate the system described in this paper. For instance, we plan to compare the automatic adaptation with the "home made" adaptation: what happens if the user can choose the new functionalities by himself? In order to evaluate the gamification adaptation to users' profiles, we plan to compare three cases:

- Case 1: Selecting game elements according to user's profile.
- Case 2: Selecting game elements randomly.
- Case 3: Selecting game elements at the opposite of user's profile.

In this way, we will be able to evaluate the relevance of the proposed adaptation (case 1).

Furthermore, some improvements will concern the flexibility of the player model. Sometimes, the player type is not enough to model the user's needs, as they can change during the day. As an example, two motivational factors of Lazzaro (2004) are detailed bellow:

- Hard fun (Players look for challenge, strategy and problem solving).
- Easy fun (Players enjoy intrigue and curiosity).

Whether we expect to relax (easy fun) or to be challenged (hard fun) depends more on our mood than our personality and player type. Some contextual information can help to know about this mood, like the hour and the day. For example, a user may expect a more relaxing activity after lunch. Furthermore, expert systems are limited as they are static. Another improvement we plan to do is the use of machine learning techniques to automatically adapt the adaptation rules themselves, based on the experience with the previous users.

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Comparing Electronic Examination Methods for Assessing Engineering Students

The Case of Multiple-Choice Questions and Constructed Response Questions

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Keywords: Assessment Methodologies, Computer-aided Examination Methods, Evaluation Algorithms, Undergraduate Engineering Modules, Scoring Rules, Multiple Choice Questions, Constructed Response Questions.

Abstract: The aim of this work is the comparison of two well-known examination methods, the first consisted of multiple-choice questions (MCQs) and the second based on constructed-response questions (CRQs). During this research MCQ and CRQ tests were created for examining the undergraduate engineering module of “project management” and were given to a group of students. Computers and a special software package were used to support the process. During the first part the examinees had to answer a set of CRQs. Afterwards, they had to answer a set of MCQs. Both sets covered the same topics and had the same level of difficulty. The second method (MCQs) is more objective in terms of grading, though it may conceal an error in the final formulation of the score when a student gives an answer based on an instinctive feeling. To eliminate this problem a set of MCQs pairs was composed taking care that each question of the pair addressed the same topic in a way that the similarity would not be evident to a student who did not possess adequate knowledge. By applying a suitable scoring rule to the MCQs, very similar results are obtained when comparing these two examination methods.

1 INTRODUCTION

Modern IT can provide a set of tools for the enhancement of the educational process such as material of digital polymorphic content and software applications (Reiser & Dempsey, 2011; Dede, 2005; Friedl et al., 2006). The penetration and incorporation of such tools in the modern academic learning practice has been widely accepted since many years (DeBord et al., 2004). It can potentially contribute to the enrichment of the traditional examination and assessment methods of students by the use of computer aided systems and the introduction of innovative examination techniques (Tsiakas et al., 2007).

Multiple Choice Question (MCQs) tests belong to the category of objective evaluation methods as the score can be rapidly calculated without putting the examiner in the position of deciding the grade. Moreover, it does not depend upon the writing speed and skill of the examinee (Bush, 2006; Freeman& Lewis, 1998; Scharf & Baldwin, 2007). The time efficiency, combined with the grading objectivity, enables the provision of prompt feedback to the examinee, after the termination of the examination, regarding the overall score along with specific information in a form of report about correct and incorrect answers.

A significant problem of the MCQs is the infiltration of the “guessing” factor during the time of selecting one of the possible answers. The application of a simple grading rule of positive score only for the correct answers and no loss for the incorrect ones could form a score that a part of it may be based on guessing or sheer luck and does not objectively reflect the student’s knowledge. A potential solution to this problem can be the application of special grading rules that may include a penalty (i.e. subtraction of points) in case of wrong answer (Scharf & Baldwin, 2007). This fact can affect the students’ behavior and mislead them in terms of decision making. Their uncertainty will eventually generate variance regarding the test scores which is related to the expectations of the examinees and not to the knowledge that is tested

(Bereby-Meyer et al., 2002; Bereby-Meyer et al., 2003).

One of the most widely used examination methods include sets of constructed-response questions (CRQs). These questions request as an answer a short text or essay. The answer is evaluated and graded by the examiner. Previous works exhibit that MCQs have the same validity as the ones coming from CRQs tests and they are at the same time highly reliable (Lukhele et al., 1994; Wainer & Thissen, 1993; Wainer & Thissen, 2001). There are two works (Ventouras et al., 2010; Triantis & Ventouras., 2011) that compare the results coming from both methods (CRQs and MCQs) that are statistically identical when using a special grading rule applied to the MCQs examination. Another work (Ventouras et al., 2011) is comparing oral examination and MCQs examination using the same special grading rule. The modules that the method was applied were core engineering courses thus there was a great interest to objectively evaluate students in order to identify any potential gaps in their knowledge that may affect their further studies. This method is based on the formulation of questions in pairs. Every pair addressed the same topic in a way that this fact is not evident to the student that did not possess adequate knowledge. A cumulative grade for the pair is calculated including bonus points if both questions are answered correctly or subtracting points as a penalty if one question is answered correctly. The aim of that scoring rule is to penalize guessing, in a way that might not positively induce the dissuading effects mentioned above, which are related to the negative marking part of the commonly used mixed-scoring schemes.

The aim of the present work is to further investigate the similarity of results when applying both methods in another engineering course and exploit the possibilities offered by the use of IT in the educational process. An objective of this work is to use MCQs examination methods, in conjunction or alternatively, with examination methods which are not suited for the PC environment, such as CR tests.

This study belongs to an ongoing research framework regarding assessment methods and parameters that can be potentially used as reliability and validity markers of the examination methods. There exist substantial indications that MC scores provide higher reliability and are as valid as scores extracted from examinations based on the CRQs method (Wainer & Thissen, 1993; Lukhele, Thissen, & Wainer, 1994). These indications would help in promoting the use of MCQs tests in most educational settings where CRQs are still used, especially taking into account the drawbacks of the CRQs examination as the subjects that might be examined cannot cover a significant amount of the material taught during the courses along with their inherent inability of introducing automated grading in essay-like responses to questions. Concerning the interest and motivation of engineering students to use new technological tools as part of their educational process an electronic examination will provide immediate results and could be an essential enhancement in the context of a larger effort already began in the Technological Education Institute of Athens of introducing computer aided and web tools for supporting teaching. This fact requires research and well defined methods for creating objective assessment methods.

2 EXAMINED COURSE AND SAMPLE OF STUDENTS

During the academic period 2012-2013, a course was selected, in order to compare the results produced by both examination methods. The course is entitled “Project Management” and belongs to the group of supplementary engineering courses taught in the Department of Electronics hosted by the Technological Educational Institute (T.E.I.) of Athens. The same group of 37 students participated in both examinations (MCQs and CRQs). All students had completed the course and polymorphic material (notes, videos, etc.) in digital format had been provided to them. Moreover, all students were familiarized with the electronic examination platform which would be used for both examinations. During the CRQs examination the students had to type their answer into the appropriate text field. For the case of MCQs examination the students had to answer the question by clicking one of the possible answers. The examination took place in a PC laboratory room using an application called “e-examination”. This application had been implemented in an effort to introduce at the Technological Educational Institute (T.E.I.) of Athens, LMS tools to support the educational process (Tsiakas et al., 2007; Stergiopoulos et al., 2006). At the end of the MCQs test an electronic report was produced for each student. This report included all questions with the correct answer and the indication of whether it was correctly or wrongly answered, as well as the final score. One copy was given to the student and one to the examiner, for processing the scores.

For the CRQs examination, a set of twenty (20) questions was created. The distribution of CRQs was designed in a way that they covered all topics taught during the course. Their difficulty level varied and a special weight in terms of grading was appointed to each one according to the level of difficulty. The total score that a student could achieve was 100 points.

For constructing the MCQs examination the questions were selected by a database that contains a large number (N=300) of questions which also addressed all the topics taught during the course. By using a special software, a first set of MCQs $\{q_{a1}, q_{a2}, \ldots, q_{ak}\}$ (k=20) was randomly selected from the database. Once again, a weight w_{ai} was assigned to each question i=1,…,k, depending on its level of difficulty. In order to form 20 pairs of questions, another set was selected from the same database $\{q_{b1}, q_{b2}, \ldots, q_{bk}\}$ (k=20). Each pair addressed the same topic and the knowledge of the correct answer for question q_{ai}, from a student who had performed a thorough study implied the knowledge of the correct answer for q_{bi} and vice versa. The total score that a student could achieve was 100 points. The examiners took special care that both examinations were of the same level of difficulty in order that the results could be comparable. During this examination all questions form pairs in order to apply the scoring rules in all the set and trying to eliminate the guessing factor from each and every one of the questions addressed by the students.

3 SCORING METHODOLOGY

As mentioned above, the CRQ's examination includes twenty questions. Each question corresponds to a certain grade according to its difficulty. The way that the student answers the question is evaluated by the teacher. The overall examination score *m1* was extracted, as the sum of the partial grades, and is by definition normalized to a maximum value of 100.

For the MCQs the score was calculated as follows: For each MCQs pair i=1,…,20, the "paired" partial score p_i is:

$$p_i = (q_{ai} w_{ai} + q_{bi} w_{bi})(1 + k_{bonus}) \qquad (1.a)$$

if both q_{ai} and q_{bi} were correct ($q_{ai}=q_{bi}=1$) or

$$p_i = (q_{ai} w_{ai} + q_{bi} w_{bi})(1 - k_{penalty}) \qquad (1.b)$$

if q_{ai} or q_{bi} was correct ($q_{ai}=1$ and $q_{bi}=0$, or $q_{ai}=0$ and $q_{bi}=1$).

$$p_i = 0 \qquad (1.c)$$

if both q_{ai} and q_{bi} were incorrect, in which case $q_{ai}=q_{bi}=0$.

The parameters k_{bonus} and $k_{penalty}$ were variables that are used for the calibration of the bonus/penalty mechanism applied to the scoring rule. For most pairs, the questions of the pair had the same weight. This means that $w_{ai}=w_{bi}$.

In some cases though, the weight of the two paired questions differed slightly (i.e., by 0.5) because it is not possible for some topics to create a pair of questions that referred to the same topic and the knowledge of the correct answer for question q_{ai}, from a student who systematically studied implied the knowledge of the correct answer for q_{bi} and vice versa and were also absolutely equal in their level of difficulty.

The total score *m2*, with maximum value equal to 100, was then computed as:

$$m2 = \frac{\sum_{i=1}^{20} p_i}{(1 + k_{bonus}) \cdot \sum_{i=1}^{20} (w_{ai} + w_{bi})} \qquad (2)$$

Therefore, for the calculation of score *m2*, a bonus is given to the student for correctly answering both questions of the pair (q_{ai} , q_{bi}) and a penalty for correctly answering only one question of the pair. In the case that a student left a question unanswered intentionally or because of running out of time, a penalty would be given regarding the pair that the question belonged to. Following this scoring algorithm, the final score corresponds to the paired MCQs examination method.

Another scoring method was applied to the same group of questions. This method is characterized by a classic scoring rule applied to MCQs examinations. When a student gave a correct answer the score that corresponded to this question was added to the overall one. Otherwise, in case of a wrong answer, the student got no points at all. This method ignores any relation existed between the questions of a pair. Moreover, no penalty or bonus was considered during the scoring process. The overall score (*m3*) for this method was calculated using the following equation:

$$m3 = \frac{\sum_{i=1}^{20} (q_{ai} w_{ai} + q_{bi} w_{bi})}{\sum_{i=1}^{20} (w_{ai} + w_{bi})} \qquad (3)$$

The weights (w) as well as the points assigned to each question in case of a correct answer remained the same. Eq. 3 is a special case of Eq. 2 when k was omitted.

4 VALIDITY THREATS

Validity is the most important characteristic of assessment data. The threats to validity are circumstances or processes that undermine the assessment. The most important threats to the validity of the study are discussed below:

The issue of poorly crafted questions is very significant as writing effective MCQs as well as CRQs which test important cognitive knowledge is a demanded task. The teacher should be able to create sets of questions comprised of the MCQ type supported by the application. This depends on the structure of the module and the nature of the examination topics. The challenge was to fragmentise big problems and exercises into MC questions covering at the same time a wide range of the module topic. The questions can be separated into groups of different level of difficulty. There was previous experience in organizing and conducting electronic examinations for the specific module (Ventouras et al., 2010).

Various testing irregularities can be that the students have prior knowledge of the test questions or that they perform unethical actions (i.e. cheating) during the examination. Such action can severely affect the score. Students from the specific department were more or less accustomed to new technologies and the use of computers. They were also familiar with the concept of MCQs examined electronically and they had access to sample MCQs tests for self-evaluation purposes. These questions were not part of the current examination. Moreover, the software package used for the electronic examination had the feature to present to each student's monitor the set of the questions along with their corresponding answers in random order. This way any attempt of cheating or communication among the examinees could be immediately apparent by the supervisor.

All students were "testwise" in terms of been familiar with the MCQ exam process. The teachers of the module had taken special care during the construction of the questions in order to create sets that could not easily answered by guessing. In any case the "paired questions" concept also contributed to the solution of this issue.

Test Item Bias refers to the fairness of the test item for different groups of students. In case that the test item is biased different group of students have different probabilities of correctly responding. For the purposes of the current study the same group of students took part in both examinations which were constructed and controlled by experienced teachers

5 RESULTS & DISCUSSION

In the present study the effects of changing the value of parameter k were investigated. Regarding MCQs examination Eq. 3 was initially used for the calculation of the MCQs examination results. This equation corresponds to the classic scoring rule meaning that no bonus nor penalty points were taken into consideration. This simplified scoring rule produced results that were higher than the ones produced by the CRQs examination. Apart from the top scores that well prepared students achieved and did not present significant differences, all other scores presented a deviation. A possible explanation could be the absence of a mechanism that fixed the "guessing" factor when answering the questions. In Figure 1 the regression line of score (*m1*) to score (*m3*) are presented. The fitting is based on a second degree polynomial. It is observed that most students' scores are above the bisector as shown in Figure 1. A fit for the score can be quantified using parameter R^2 which is related to the regression line of CRQ score of each student (*m1*) to the MCQ score (*m3*) of the same student. Its best possible value is 1. The value of R^2 for this case is equal to 0.9554.

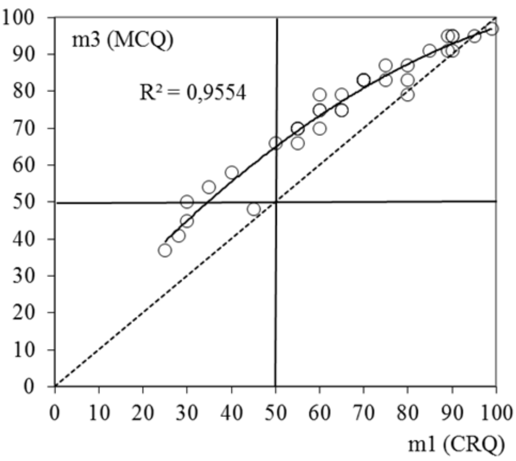

Figure 1: Regression line of CRQ score of each student (*m1*) to the MCQ score (*m3*).

It must be noted that in order to have comparable results, students had been informed that incorrect answers did not have any additional penalty in terms of negative marking. This way they were encouraged to attempt answering any questions that might have a rough knowledge on the topic. During this examination the students were not aware of the scoring rule based on paired questions as this knowledge might be a factor that affect decision making under uncertainty. In turn, this might produce variance in the test scores that is related to the expectations of the examinees and not to the knowledge that is tested (Bereby-Meyer et al., 2002; Bereby-Meyer et al., 2003). The final report produced by the system included only the scores calculated based on the classic scoring rule meaning that no bonus nor penalty points were taken into consideration (*m3*).

The bias that is probably caused by the "guessing" factor is clearly corrected when using the scoring rule of paired questions. This is shown in Figure 2 if the regression line is compared to the one shown in Figure 1. An attempt to find the optimal values was made in order to have a better fit of the scores achieved by the examinees during both examination methods. For this the case the k_{bonus} and $k_{penalty}$ parameters are considered as one parameter k. This means that the same value is assigned to both parameters. This value is added to the score if the student correctly answered both questions of the pair and it is subtracted if the student failed to correctly answer one question of the pair. The results produced by the system were only available for the examiners in order to perform the research.

Table 1: Results of the examination methods.

CRQ method	MCQ method (paired questions)				
	k=0.26	k=0.28	k=0.30	k=0.32	k=0.34
64.97	65.50	65.14	65.20	64.70	64.41

In Table 1 the results using CRQs and MCQs with paired questions are shown. For the MCQs examination method different values of k parameter were set when calculating the overall score of each student using Eq. 2. It is shown that for the parameter $k = k_{bonus} = k_{penalty} = 0.30$ the mean value of the distribution of scores calculated for the MCQ method is very close to the mean value of the distribution of scores of the CRQ method. This is in agreement with the results of previous electronic examinations using the Bonus/penalty scoring methodology (Triantis & Ventouras, 2011). Further research and more examination results of various courses are required in order to evaluate the optimized value parameter k which seems to be approximately equal to 0.3. A fit for the score can be quantified using parameter R^2 which is related to the regression line of CRQ score of each student (*m1*) to the MCQ score (*m2*) of the same student. Its best possible value is 1. In Figure 2 the regression line of score (*m1*) to score (*m2*) are presented for k=0.30. It is observed that R^2 remained at a high level (> 0.98) close to a value equal to 1 for $0.30 \leq k \leq 0.34$.

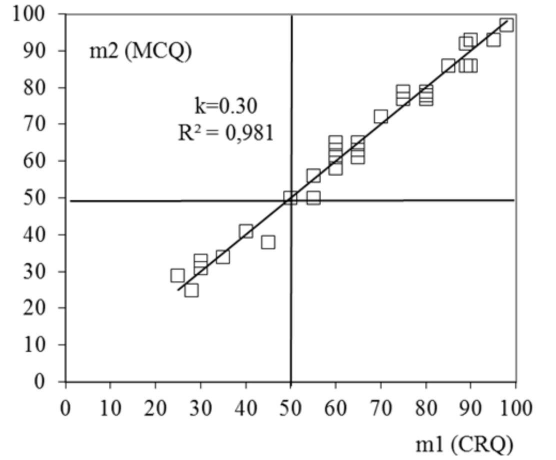

Figure 2: Regression line of CRQ score of each student (*m1*) to the MCQ score (*m2*).

A metric related to the variation of the k parameter value is the sum of the squared differences of the students' scores during MCQs (paired questions) and CRQs examination. The sum of squared error (SSE) is calculated by the following equation:

$$SSE = \sum_{j=1}^{37} (m1_j - m2_j)^2 \quad (4)$$

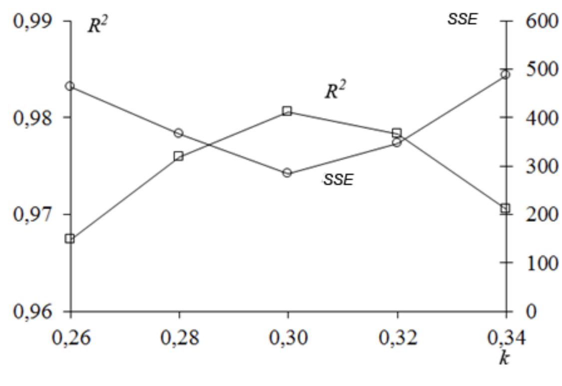

Figure 3: Sum of squared differences of *m1* and *m2* as related to k parameter. R^2 related to k parameter.

The optimum value that the sum could have reached was zero. In Figure 3 is shown that the function of sum to parameter k is smoothly varying within the space of *k*=0.26 and *k*=0.34 having a minimum at *k*=0.30. This value of k parameter is the optimum one to apply to the scoring rule. In the same figure the relation of R^2 to parameter *k* is also shown. It is observed that the maximum value of R^2 was also found for *k*=0.3. This value which seems to be the optimal one and has been also observed during the implementation of this method to other modules already published (Ventouras et al., 2010; Triantis & Ventouras., 2011) and optimses the students' overall score in a way that they objectively reflect their level of knowledge.

6 CONCLUSIONS

Electronic examinations supported by special software tools are very helpful for the educational process as they provide the means for the automatic production of the results and the ability to easily apply different scoring rules. This way the lecturer can have a clear image of the results which may be used for optimizing the way of teaching and disseminated material.

During the comparison of the CRQs examination method and the MCQs examination method it was observed that the classic scoring rule of positive score for correct answers introduced a bias due to the failure of eliminating the "guessing" factor, a common phenomenon of MCQs examinations. Therefore, such a simple scoring rule cannot advance MCQs examination for potentially substituting a CQRs examination method. Nevertheless, by applying a scoring rule that introduces the use of a special parameter that its value is added or subtracted to the overall score according to the correct or wrong answers along with the concept of pairs of questions addressed the same topic, can give results that are very close to the ones produced by the CQRs method. To the extent of the results of the present study, indication is provided that a value of k parameter approximately equal to 0.3 can optimally give results that clearly and objectively reflect the level of student's knowledge.

The key factor for applying this rule is a thorough preparation of the questions from the examiner in such a way that they cover all topics of interest and can form pairs in a way that their relation to a specific topic will not be evident to a student that is not well prepared.

Part of future work will be the research on results when assigning different values to k_{bonus} and $k_{penalty}$ parameters, respectively. During this research an algorithm might also designed for enhancing the electronic examination application by automatically selecting the optimized value of *k* parameter. The scoring rule has to be tested in other modules as well in order to further verify its usefulness as an objective evaluation tool.

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Synthesis of a Framework of Design Guidelines for m-Learning Environments

A Study in a Tertiary Education Context in South Africa

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Keywords: Design and Development Strategy, Design Guidelines, Digital Devices, m-Learning Environment, Tertiary Education, Virtual Learning Environment.

Abstract: Smartphones and tablets are ubiquitous in educational contexts, where students on-the-move expect access to learning material via a range of digital devices in a mobile and transparent manner, whether on or off campus. A successful m-learning experience can be facilitated by a mobile learning environment which is efficient and effective, and that satisfies the users' versatile needs. An *ad hoc* design and development strategy that ignores design principles and guidelines, restricts the likelihood of successful m-learning experiences. This study was implemented in a tertiary education context and aimed to establish – from dual perspectives – a framework of design and development guidelines for m-learning environments. An initial set of themes and guidelines was synthesized from a comprehensive literature study. Secondly, the outcomes of a series of iterative evaluations of an m-learning application, *Mobile Learning Research* (*m-LR*) were used to generate new themes and guidelines. The quantitative and qualitative findings of heuristic evaluations by experts and questionnaire surveys administered to students, provided positive and negative feedback that was converted to a set of practical guidelines. Jointly, the initial theoretical guidelines and the subsequent empirical findings contributed to the synthesis of a comprehensive and cohesive set of design guidelines for m-learning environments.

1 INTRODUCTION

Smartphones and tablet devices offer ubiquitous m-learning opportunities for higher-education students who study while on-the-move (Cochrane and Bateman, 2010). Over and above educational aspects, the perceived usability and user experience (UX) of m-learning platforms depends to a large extent on underlying design and development factors (Oinas-Kukkonen and Kurkela, 2003). This study, which proposes a framework of design guidelines for the synthesis of m-learning environments, is a secondary outcome of the iterative development and evaluation of a real-world learning environment called *Mobile Learning Research* (*m-LR*) (Harpur, 2013, de Villiers and Harpur, 2013). A *first set* of design guidelines for m-learning was gleaned from the literature and used to generate the first version of *m-LR*. The purpose of this paper is not primarily to report on the evaluation and redesign of *m-LR* prototypes. However, the findings of the evaluations formed a vital part of the design process and the emergence of *a second set of guidelines*.

Ad hoc approaches that ignore design principles in the development of m-learning, may have unfortunate usability and UX implications that designers and developers of the end-product could regret. This study contributes to knowledge by synthesising a framework of design guidelines that incorporates theoretical guidelines based on acknowledged literature sources, as well as practical guidelines from the findings of empirical evaluation studies. Participants' responses identified problems in *m-LR* and also provided positive feedback. The composite set of guidelines, emerging from both theory and research, offers a rich broad-based collection of design guidelines that is transferable and adaptable to various mobile- and tablet-based learning situations. Through use and evaluation of *m-LR*, the theoretical guidelines were affirmed by use and new ones emerged.

Section 2 sets the context and outlines the background of this research. The research design is described in Section 3. Thereafter we view the guidelines from three lenses: their emergence; application; and evolution. Section 4 lists the initial guidelines that *emerged* from a literature review, while the impact of practically *applying* the guidelines, is reported in Section 5. Section 6 presents further guidelines that *evolved* from evaluations. The study is concluded in Section 7.

2 BACKGROUND

The primary researcher is a lecturer of undergraduate students taking Software Engineering at a private South African university. She observed that some students seemed demotivated by traditional face-to-face classroom education. In addition, the limited access of certain students to the Internet via PCs and laptops hindered effective communication and collaboration on group projects. However, the majority of students had smartphones and/or tablet devices and were proficient in the use of digital technology. They depended on these when they returned home and contributed to group projects from a distance, thus converting their mode of study to blended learning. This suggested that a technology-enhanced mobile learning solution might enrich their learning experience, therefore the researchers set out to custom-build an initial m-learning prototype, version *m-LR*$_1$, on a Moodle platform, a distributed digital learning environment, suited to m-learning requirements. Even though distributed digital learning environments such as Blackboard and Moodle provide support for anytime- and anywhere-learning, pertinent design issues include:

- The difficulty of integrating course material from different sources;
- The unwieldy size of digital learning systems;
- Maintenance pressures due to continual addition of learning content;
- A need to accommodate scalability and security requirements;
- Network problems; and
- Limitations posed by the delivery of large multimedia and course content (Li et al., 2008).

Guidelines were sought for producing and improving the prototype to optimise the effect of adaptations and to avoid an a*d hoc* design and development strategy. Despite an extensive literature study, no single appropriate design and development methodology was found.

A decision was therefore taken to synthesize a set of design guidelines in parallel with the development of the m-learning environment. Ethical clearance for the research was obtained from the institution where it was conducted and from the university where the primary researcher was enrolled for postgraduate studies.

3 RESEARCH DESIGN

The research paradigm used to generate *m-LR*, was design-based research. 'Design science' originated from the Nobel prize winner, Herbert Simon (Simon, 1981). It led in turn to 'design research', which investigates artificial phenomena and solves complex problems by creating and evaluating man-made products.

In the discipline of Information Systems, research of this nature is termed 'design science research' (DSR) (March and Smith, 1995, Peffers et al., 2007), and in the educational technology milieu, is called 'design-based research' (DBR) (Barab and Squire, 2004, Amiel and Reeves, 2008, Anderson and Shattuck, 2012). DBR is appropriate for pragmatic contextual research in complex domains, and is implemented by iterative cycles of empirical studies. It has dual outcomes in the form of (i) useful authentic products and (ii) theoretical contributions that are transferable to other environments. In this research, the practical outcome was *m-LR* and the theoretical outcome was the set of design guidelines, which are the contribution addressed by this paper.

3.1 Research Question

The following research question was thus posed:

What are appropriate guidelines to use for the design and development of m-learning environments?

The process of answering the question is shown in Figure 1, which depicts the iterative development and evaluation processes of *m-LR* versions: *m-LR*$_1$, *m-LR*$_2$, *m-LR*$_3$, *m-LR*$_4$, and a future final one, *m-LR*$_F$.

This research reflects on these four versions and four iterative studies: Evaluation Study 1, Evaluation Study 2, Evaluation Study 3 and Evaluation Study 4.

3.2 Research Methods

Evaluations and Participants

The research was conducted over two and a half years and entailed evaluations by two different methods amongst two kinds of participants.

First, heuristic evaluations (HE's) were undertaken, in which between three and five experienced evaluators, so-called 'experts', study a system to identify problems and strengths (Nielsen and Molich, 1990, Nielsen, 1992). Different heuristic evaluators were hand-picked for each of the four studies. All of them were experts in HCI or in digital education or both, so-called 'double experts'. The numbers of heuristic evaluators in the studies were in line with Nielsen's recommendations.

Second, questionnaire surveys were conducted amongst end-users, i.e. using students as evaluators. In the first two evaluation studies, samples of experienced software engineering students were purposively selected to participate, while in the third and fourth studies, entire cohorts were used, i.e. the participants were a population, not a sample.

Furthermore, Evaluation Studies 1 to 3 were conducted on a suburban campus of the university, while Evaluation Study 4 was done on two different campuses of the institution – the suburban one, as well as a campus in an urban area, which was less affluent. This enriched the findings by administering questionnaires to two varying cohorts.

The use of these research methods aimed to achieve method triangulation (two different methods) and data triangulation (across two different campuses). The evaluations are described in detail in Section 5.1.

Evaluation Procedure and Tasks

The iterative approach provided sequential evaluations of the usability and user experience of four different versions of the m-learning environment.

Prior to conducting the evaluations, participants – both expert evaluators and students – completed a defined series of software engineering activities via mobile devices. This familiarised them holistically with the features of *m-LR*, enabling them to effectively evaluate versions of the *m-LR* platform. These activities included: secure login; exploration of specific software engineering course content; a brief review of a lesson, completion of a quiz associated with the lesson; entry of a blog comment; contribution to a forum discussion; a search for particular terms in a glossary; participation in a software engineering chat session; a contribution to a wiki topic; and the viewing of online media. This comprehensive exposure was crucial in helping them contribute meaningfully to the development of new guidelines. The resulting practical guidelines, which reflect findings of the evaluation processes, are presented in Section 6.

Research Instruments

The questionnaires were not adaptations of a standard instrument. Instead the evaluation criteria were custom-developed, based on five categories, namely: general interface criteria; pedagogical aspects; website specific criteria; factors specific to m-learning; and user experience (UX) criteria. A separate publication is in progress, focusing on the generation of these criteria.

Constructs in the questionnaires were based on these categories. There were evaluation statements using a 5-point Likert scale, as well as open-ended items for qualitative responses. The HE's by experts and questionnaire surveys amongst end-users thus provided both quantitative and qualitative data. The questionnaires and evaluation criteria are not included in an appendix, because they are too long.

The quantitative data analysis and the qualitative thematic analysis of free text identified usability and UX problems as well as highlighting positive factors. This led to a set of practical guidelines, specific to the design of m-learning environments.

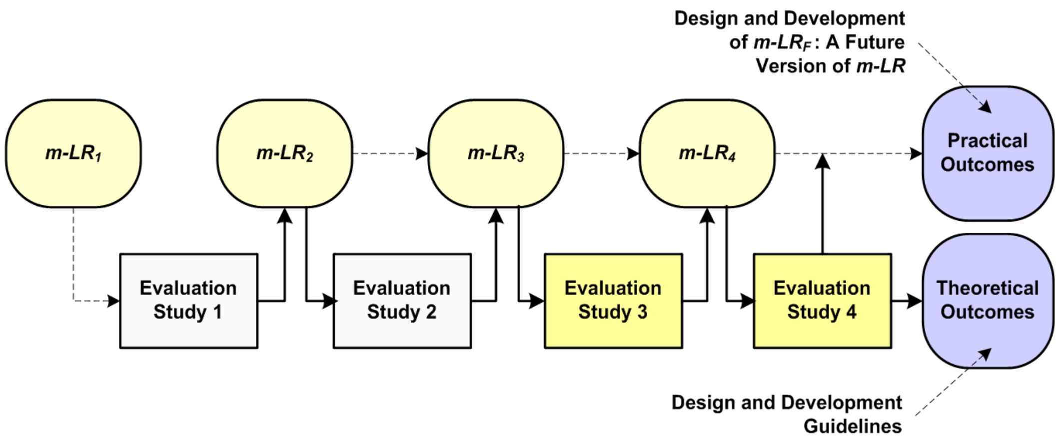

Figure 1: Development of *m-LR* through four versions and four evaluation studies.

3.3 Derivation of Design Guidelines

As previously mentioned, the guidelines emerged from two types of sources. Firstly, existing guidelines were garnered from pertinent literature and synthesized into an initial framework (Section 4), presented in Table 1, i.e. the literature served as secondary data. Secondly, empirical research was undertaken (Section 5) by evaluating versions of *m-LR* as described in Section 3.1 and illustrated in Figure 1. The findings of these evaluations (Section 6) were used as primary data to generate Table 3, which extends and completes the framework.

4 INITIAL GUIDELINES EMERGING FROM THE LITERATURE

Literature sources address various challenges within m-learning domains, including the issue of appropriate design guidelines for m-learning applications. The literature study underlying this study was comprehensive, being both broad and deep.

The work of many researchers contributed to the formulation of the initial collection of guidelines. Space constraints preclude detailed discussion of all the sources consulted, but we specifically mention contributions from certain acknowledged researchers such as:

- Botha, van Greunen and Herselman (2010): *mobile learning interactions viewed from an HCI standpoint*;
- Ebner (2009): *inclusion of Web 2.0 features such as microblogging in mobile learning*;
- Oinas-Kukkonen and Kurkela (2003): *developing successful mobile applications*; and
- Sharp, Rogers, and Preece (2007): *a focus on interaction design*.

The overall literature review resulted in the structured synthesis of an initial set of design and development guidelines, which are presented in Table 1. This table plays an important role in this paper, in that it is the first version of the framework of design guidelines, namely the contribution that emerged from theory. The initial framework comprises eight categories of guidelines.

Within each category, key terms are italicised to emphasise the contributions made by various authors. The contributing authors are cited in alignment in the third column.

Table 1: Design guidelines for m-learning environments – emerging from the literature.

	Design and Development Guidelines	Literature Sources
1 Strategy	▪ Provide *interactivity* via UCD	Göker and Myrhaug (2008)
	▪ Improve the environment by implementing *iterative design*	
	▪ *Involve experts* in contributing to the design	Bri, Garcia, Coll and Lloret (2009)
2 Mobile Specifications	▪ Provide *accessible information* to students whilst they are moving to and from locations, around campus, in the classroom, and between the outside world and the university	Oinas-Kukkonen and Kurkela (2003), Sharma and Kitchens (2004)
	▪ Focus more on *content and m-learning* than on technology	Landers (2002), Pinkwart, Hoppe, Milrad and Perez (2003)
	▪ *Link tasks* to course content	Parsons, Ryu and Cranshaw (2006)
	▪ Support *social networking* and learning, seamlessly	Landers (2002), Parsons, Ryu and Cranshaw (2006), Sharma and Kitchens (2004)
	▪ Include *mobile specifications* with accessibility via all devices	Low and O'Connell (2006)
	▪ Aim for compatibility with a *wide range of media*	Landers (2002), Parsons et al.(2006)
	▪ Incorporate *security* and *privacy* features	Naismith, Lonsdale, Vavoula and Sharples (2004), Pinkwart et al. (2003)
3 User-centricity	▪ Involve end users in guiding the *design of the interface*,	Sharp, Rogers, and Preece (2007)
	▪ Consider *users' understanding* of terminology and navigation	Oinas-Kukkonen and Kurkela (2003)
	▪ Incorporate *usefulness* from a user's perspective	
	▪ Allow *customisation* and *adaptability* for each user's preferences, needs and abilities	
	▪ Include features that enhance *motivation*	Botha, van Greunen and Herselman (2010)

Table 1: Design guidelines for m-learning environments – emerging from the literature (Cont.).

	Design and Development Guidelines	Literature Sources
4 Ease of Use	▪ Focus on *simplicity* and *flexibility*	Oinas-Kukkonen and Kurkela (2003), Sharma and Kitchens (2004)
	▪ Aim for easy *assimilation* on the part of the student	Bri et al. (2009)
	▪ Facilitate *availability* of important information	
	▪ Present only the *essential* and consistent *information*	Low and O'Connell (2006)
	▪ Make provision for *evaluation* of usability	
	▪ Implement fluent *navigation*	
5 Content	▪ Include self-contained '*chunks*' of educational material; ▪ Provide content in *accessible* and *compact formats*, presented in multiple ways	Low and O'Connell (2006), Sharma and Kitchens (2004)
	▪ Provide facilities that accommodate *communication* and *collaboration* within learning	Bri et al.(2009)
	▪ *Ground the content* in teaching and learning	Botha, van Greunen and Herselman (2010), Bri et al.(2009), Cheung (2009)
6 Context	▪ Take cognizance of *mobility levels*, usage mode, time and place of learning, budget, and network connectivity factors;	Botha et al. (2010), Oinas-Kukkonen and Kurkela (2003)
	▪ Plan for *in-situ learning* associated with new, individual and team skills with social interaction;	Parsons et al. (2006)
	▪ Incorporate *a selection of screen and keyboard/touch options*, operating systems, device types, network configurations, and student characteristics.	Botha et al. (2010)
7 VLEs	▪ Ensure that the environment reflects academic vision and offers relevant *curriculum content*, providing training and support for staff and students	Cheung (2009)
	▪ Resolve *copyright* and *intellectual property* issues	Levy (2003)
	▪ Rapidly provide value in a natural way via *mobile services*	Bri et al. (2009), Oinas-Kukkonen and Kurkela (2003)
	▪ Consider that *digital technology* has changed students' views of writing in the "old-fashioned" way. Current strategies differ from "pencil and paper" lessons	Lai, Yang, Ho and Chant (2007), Pinkwart et al. (2003)
	▪ Offer *uniform access* to a variety of information sources, e.g. websites, glossaries, reading material, relevant YouTube videos, other student opinions	Bri et al. (2009), Pinkwart et al. (2003)
8 Web 2.0 Tools	▪ *Extend* the student's *classroom* experience	Ebner (2009)
	▪ Include *Web 2.0 features* e.g. podcasts, blogs, microblogs, wikis, and social networking sites (SNSs)	Ebner (2009), Ebner and Schiefner (2008), Lockyer and Patterson (2008), Minocha and Thomas (2007), Safran (2008)
	▪ Emphasize the *planning* required for implementing social networking applications within an online educational program	Lockyer and Patterson (2008)
	▪ Facilitate *communication* and *collaboration* via synchronous technologies (chat rooms) and asynchronous interactivity (forums and e-mail)	Jones (2010), MacCallum and Kinshuk (2008), Minocha and Thomas (2007)

5 EMPIRICAL STUDIES

5.1 Evaluation Studies

The guidelines in Table 1 were used in generating four versions of a mobile learning environment: *m-LR*$_1$, *m-LR*$_2$, *m-LR*$_3$, and *m-LR*$_4$, with a view to a future version, *m-LR*$_F$. These versions can thus be considered applications of the guidelines.

Figure 1 in Section 3 showed the four sequential evaluation studies – Evaluation Studies 1, 2, 3, and 4 – that were respectively implemented on the four successive versions of *m-LR*. Participants in these studies were experts who served as heuristic evaluators and students who completed questionnaires. A brief description is now provided of each study, explaining its context and purpose. However, the findings reported in the next section, Section 6, focus exclusively on findings of the final two studies, Evaluation Study 3 and Evaluation

Study 4, which impacted strongly on the evolution of further guidelines.

Evaluation Study 1: As the study in 2010 that evaluated the usability of the first version of *m-LR*, a Moodle customised in an *ad hoc* manner, Study 1 uncovered usability challenges. Its purpose was to evaluate *m-LR₁* running on the researcher's own Blackberry 9700 smartphone device, and to produce both quantitative and qualitative findings. Participants were three experts for an HE and ten students in a questionnaire survey, all drawn from a single campus. Subsequent changes to $m\text{-}LR_1$, included redesign of:

- Course content, providing information in chunks for viewing on mobile devices;
- Log-in features;
- Quantity of information per page;
- Formats of downloadable media and subject matter;
- Contents of the glossary.

Adjustments to the $m\text{-}LR_1$ version led to $m\text{-}LR_2$.

Evaluation Study 2: This small-scale evaluation of $m\text{-}LR_2$ in 2011, was a pilot study for the major Evaluation Study 3. Study 2 was implemented on a single campus with only four students (questionnaires) and one double expert (HE), As in Study 1, each used the same Blackberry 9700 smartphone for their evaluation. Study 2 primarily served to try out the research procedures, tasks, instruments and evaluation processes, but did lead to improvements in the:

- Privilege levels of the blog;
- Options offered by the glossary;
- Look-and-feel facets such as font styles, size and colour;
- Open-ended requirements for the quiz.

The refinements resulted in $m\text{-}LR_3$.

Evaluation Study 3: This study in 2011, was the largest up to that point. Five HE experts, with their own devices, and seventeen students from one campus, using Blackberry 9700 smartphones, evaluated $m\text{-}LR_3$ for usability and UX. Adjustments and extensions resulted in the next version of *m-LR*, namely $m\text{-}LR_4$. Feedback called for new functionalities or changes to:

- The help functionality;
- Built-in documentation;
- Links and navigation mechanisms;
- 'Breadcrumbs', and thus navigability;
- Compatibility of media such as video;
- The range of device types, which needed to be broadened;
- File size, aiming to reduce buffering issues;
- Layout of goals and objectives of learning units;
- Offline reading capability, required by users;
- Access to social networking applications

A growing need for storage and collaborative services via cloud technology such as Dropbox and Google Drive became apparent. It was suggested that the addition of these services would increase the appeal of *m-LR* whilst facilitating communication between teams of students doing collaborative projects.

Evaluation Study 4: This final, and largest, 2012 study used $m\text{-}LR_4$ as input. Its feedback engendered guidelines that, if applied, would produce a future improved version, $m\text{-}LR_F$. Five experts and 33 students from two different campuses completed evaluations, proposing modifications to the:

- Application design;
- Specifications, as participants required compatibility with several device types;
- The user experience, which could be enhanced by improving ease of use.

Despite the high number of participating evaluators, only a few problems were reported, indicating the success of the iterative evaluation and redesign process.

5.2 Aspects of *m-LR*

Figures 2 illustrates learning aspects of *m-LR* such as: topics and lessons; activities – chats, forums, glossaries, online self-assessment quizzes, resources

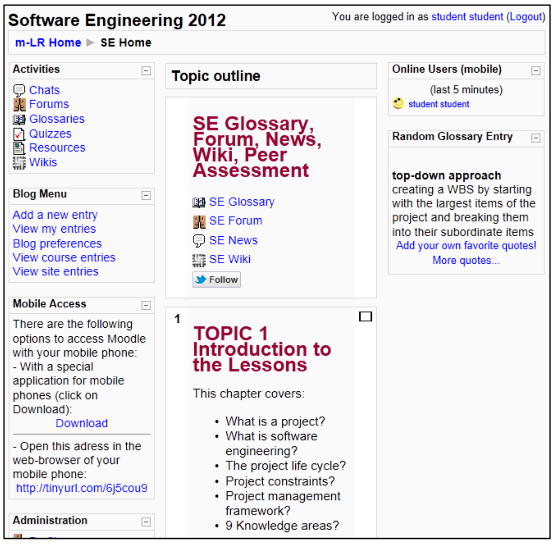

Figure 2: Homepage for the 2012 Software Engineering course.

(content and media), and wikis. These features provided team members with collaborative opportunities, extending the classroom experience to incorporate Internet links to course related websites.

Figure 3 presents a view of a student response to a self-assessment quiz item, demonstrating immediate feedback.

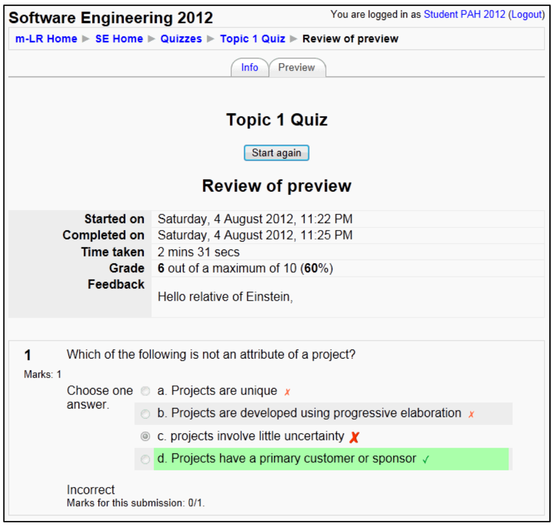

Figure 3: Self-assessment quiz with digital feedback.

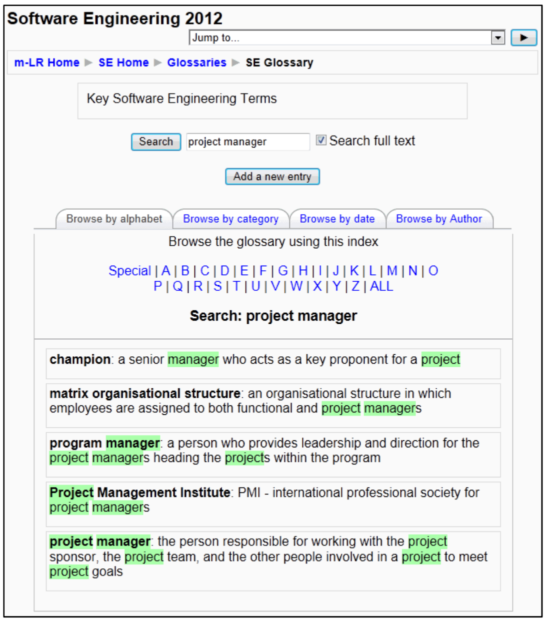

Figure 4: Key software engineering terms stored conveniently in a 'mobile' glossary – easily accessible via mobile device.

A search for term 'project manager' in a software engineering glossary is shown in Figure 4, where 'Add a new entry' indicates how students participate in formulating the glossary.

5.3 Positive and Negative Feedback

Table 2 moves the overview away from the four studies in Figure 1 and focuses on Evaluation Studies 3 and 4, indicating the positive progress made as *m-LR* evolved.

Table 2: Positive and negative feedback leading to the synthesis of new guidelines.

	Positives	Negatives	New guidelines
Evaluation Study 3 (n=22)	74	87	25
Evaluation Study 4 (n=38)	132	90	18

In Evaluation Study 3, the number of negative comments (87) exceeded the positives (74). In Evaluation Study 4, there were more positive comments (132) than negatives (90). This occurrence, despite the fact that there were almost twice as many evaluators in Study 4, suggests that the adjustments made after Study 3 were effective.

In particular, qualitative analysis showed that the number of problems identified in the *Ease of Use* category, decreased from 33% of the negative feedback in Evaluation Study 3 to 26% of the negative feedback in Evaluation Study 4.

Furthermore, two additional categories are singled out, namely: *Strategy* and *Mobile Specifications*. For Evaluation Study 3 and Evaluation Study 4, the *Strategy* category contributed 14% and 22% respectively to the total number of problems. Problems reported in the Mobile Specifications theme increased from 7% (Evaluation Study 3) to 22% (Evaluation Study 4). The increase in reported problems in these two categories can be ascribed to three factors: a dynamically changing digital environment; greater technical acuity of the participants; and a more techno-savvy attitude to mobile technology design concepts.

As stated, the primary purpose of this paper is not to serve as an evaluation study but to use evaluation findings to derive generic design guidelines. *m-LR* provided a platform requiring evaluation, while the findings of the evaluations led, in turn, new guidelines that are presented in the next section.

6 EVOLUTION OF NEW GUIDELINES

An overview of four iterative evaluations was presented in Figure 1. Positive factors that emerged from these evaluations affirm the original guidelines, while yet other positive aspects, spontaneously articulated by participants, suggest implicit strengths that should be made explicit by new guidelines. Similarly, problems that emanated from the evaluations, suggest further required guidelines. If the resulting new guidelines, particularly those that come from qualitative findings, are consolidated into a framework along with the original eight synthesised from the literature, the result would be sixteen themes of guidelines.

These new aspects are now addressed in detail, as emergence of the original set of guidelines is reviewed, and the evolution of the additional sets, particularly from Studies 3 and 4, is set out.

6.1 Emergence of the Original Theoretical Guidelines

Table 1, which presented an initial framework of theoretical guidelines for the design and development of m-learning environments, comprised eight themes, namely: 1 *Strategy*; 2 *Mobile specifications*; 3 *User-centricity;* 4 *Ease of use*; 5 *Content*; 6 *Context;* 7 *Virtual learning* eight themes,

Table 3: Guidelines emerging from findings of Evaluation Studies 3 and 4.

Theme	Guidelines	Theme	Guidelines
9 Devices	▪ Use technology to enhance, rather than hinder, *learning experiences* ▪ Ensure *compatibility* with a range of devices ▪ Support *easy access* ▪ Consider the limitations of *input mechanisms* ▪ Consider *screen size* when incorporating features	13 Interactivity	▪ Enable 'on-the-fly' *communication* with classmates ▪ Support *visibility* of other online students ▪ Facilitate *collaboration* on group projects ▪ Allow *sharing* of information ▪ Include alternative forms of interactivity, designed to suit *user preferences*
10 Assessment	▪ Provide opportunities for *self-assessment* ▪ Provide *lecturer support* for the correction of errors in such self-assessment ▪ Include *multiple choice questions* ▪ Consider the possibility of *short-answer questions* ▪ Locate *quiz* options with associated course content ▪ Incorporate *rapid test feedback* to support students doing revision while on the move ▪ Provide links to online material to facilitate preparation of *coursework* assignments ▪ Align assessment exercises with *examination preparation*	14Visual Factors	▪ Provide a simple and appealing *layout* ▪ Design a *look and feel* that is user-centric ▪ Implement suitable *colour schemes* ▪ Make effective use of *white space* ▪ Where possible and appropriate, enhance the experience with suitable *graphic content*, *headings* and *font choices* ▪ Strengthen the visual experience, possibly including some *animation* ▪ When constructing a site, design for *logical* page *order* ▪ Create a *professional learning environment*
11 Efficiency	▪ Ensure *speedy loading* of site and pages ▪ Provide *immediate responses* for users accessing features of the application ▪ Achieve *fast navigation* between links ▪ Aim for *rapid content delivery*	15 Innovation	▪ Offer the user an environment which is perceived as *new and novel* ▪ Facilitate off-campus *mobile learning* ▪ Deliver course content in a *creative* ~~*and novel*~~ *digital manner*
12 Navigability	▪ Facilitate *easy and intuitive* navigation ▪ Ensure visibility of *links* ▪ Support *browsing* – anytime and anywhere	16 Satisfaction	▪ Create a match to user's view of *suitability* ▪ Embrace the user's sense of *excitement* ▪ Provide *consistency* with familiar applications and interfaces to avoid user frustration ▪ Focus on easy *readability* ▪ Establish an *easy-to-follow flow*, starting with an introduction and progressing logically to module sections ▪ Build a learning environment which offers *enjoyable user experiences* ▪ Ensure that *functionalities* operate correctly

namely: 1 *Strategy*; 2 *Mobile specifications*; 3 *User-centricity;* 4 *Ease of use*; 5 *Content*; 6 *Context;* 7 *Virtual learning environments*; and 8 *Web 2.0 tools*. These initial themes and guidelines were used in the development of the first version, *m-LR*$_1$, and also contributed, along with findings of the series of evaluations, to adjustments and improvements of subsequent versions of the mobile learning environment.

6.2 Guidelines from Evaluation Study 3

The evaluation of usability and UX of *m-LR*$_3$ in Study 3 by 22 participants produced positive and negative feedback, resulting in practical principles and guidelines that led to the development of version *m-LR*$_4$.

The positive results of the evaluation served two purposes. Firstly, they affirmed the utility of the initial framework of theoretical guidelines and, secondly, the positive response that emerged for aspects of *m-LR* that had been designed intuitively, showed the need to concretise and formalise certain implicit guidelines. Negative feedback and concerns indicated inadequacies in the design and highlighted the need for further guidelines. Thematic analysis of qualitative data, positive and negative, confirmed existing guidelines, while other evaluation findings were converted to five new categories of guidelines, namely: 9 *Devices*; 10 *Assessment*; 11 *Efficiency*; 12 *Navigability*; and 13 *Interactivity*, which are elaborated in Table 3.

6.3 Guidelines from Evaluation Study 4

The evaluation of *m-LR*$_4$ was a major study, with 38 participants, namely five experts and 33 students from cohorts on two campuses. Due to the improvements implemented to *m-LR*$_3$ after Study 3, the number of negative issues decreased, while positive feedback increased, as shown in Table 2. Moreover, negativity previously indicated by some initial themes namely: *Mobile Specifications*; *User-centricity*; and *Ease of Use* declined, probably due to the strength of the version *m-LR*$_4$, that had resulted from Evaluation Study 3.

Only three new categories of guidelines resulted from the findings of Evaluation Study 4, namely; 14 *Visual Factors*; 15 *Innovation*; and 16 *Satisfaction*.

Finally, suggestions emerged from Study 4 for improvements to *m-LR*$_4$ that would result in a future version *m-LR*$_F$.

6.4 Evolution of Guidelines and Extension to the Framework

The new categories of themes and design guidelines, introduced in Sections 6.2 and 6.3, are listed in Table 3. The original themes that re-emerged are not included, since they are already in Table 1. This table, which is the contribution that emerged from practical empirical research, continues the evolution of the framework of design guidelines.

6.5 Final Set of Guidelines

An integration of Tables 1 and 3 would constitute the final and comprehensive set of guidelines in sixteen categories for the design and development of mobile learning environments. Such a merged table of final guidelines, though valuable, would be repetitive and, for the sake of space, is explicitly omitted from this paper.

7 CONCLUSIONS

This study addressed the following research question:

> *Which guidelines should be included in a framework for the design and development of m-learning environments?*

An aggregation of the themes and guidelines in Tables 1 and 3, where theoretical sources from the literature and practical empirical findings, respectively, contributed to the synthesis of a final set of guidelines, demonstrate that the research question has been answered.

The goalposts moved over the duration of the studies, and the target audiences became more 'techno-savvy'! Although students were increasingly satisfied with the successive versions, the later feedback began to address sophisticated *refinements*. It appeared that the users were expecting similar functionality and features in a basic system designed by an academic, to what is encountered in commercial apps!

Rapid methods of evaluation, synthesis, adaptation and evolution will depend on a comprehensive and malleable set of design and development guidelines for *effectiveness*.

Moreover, students who are mobile and on-the-move expect fast and dynamic virtual learning environments which demonstrate *flexibility*. The evolution of the integrated multi-facetted set of guidelines is in line with these requirements.

The perspectives of a variety of evaluators (content and application developers, students, lecturers, administrators, e-learning experts) contributed to participative evaluation findings that led to iterations of redevelopment of a successful mobile learning application. The empirical findings of this study show that the varying expertise and idiosyncrasies of participants provided a broad spectrum of issues and positive contributions. A *design and development strategy* should accommodate the viewpoints from each of these user groups.

Due to the dynamic and rapidly evolving nature of mobile technology, the task of formulating a set of guidelines is unlikely to be complete. Hence the framework synthesized in Tables 1 and 3, begs *augmentation* over timelines and application within other tertiary education contexts. Moreover, it is likely that different device types will be brought to the classroom.

The application of the guidelines will evolve further as capabilities and affordances of new technologies are accommodated. Furthermore, it is acknowledged that the current framework is lengthy due to its comprehensive nature. Synthesis of the categories into a tighter framework could facilitate *practical application*. Finally in transferring the application of the guidelines to other mobile environments, they can be reduced and customized to the context and content.

Whereas literature sources may provide an initial foundational set of guidelines based on theoretical underpinnings, this study demonstrates that empirical findings based on participative *user-centric designs* can extend and enrich a framework of design guidelines.

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Looking for Usage Patterns in e-Learning Platforms
A Step Towards Adaptive Environments

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Keywords: Blended Learning, Problem based Learning, Software Engineering, Education, Ecosystem of Learning, Self-directed Learning, Gamification, Scaffolding.

Abstract: This paper studies the student view of functionality offered by a research-based design of a blended learning environment. The course in question is a Software Engineering course at the Cooperative State University students alternate between study and work in a quarter-based system and complete their study in three years. Based on findings over the last year, the course is currently using an e-learning platform (Coursesites by Blackboard) to enhance the on-site classroom experience. For this paper, students were asked to rate the usefulness of various functionalities offered by the platform. The results of the survey (77 students) are then used to explore patterns of usage. We use Grasha's theoretical definition of six learner-stereotypes to derive an exaggerated usage pattern for each. While students do not match stereotypes, usage patterns become evident in the degree to which they match a combination of these pure definitions. According to groupings of common manifestations, the student body is highly fragmented in their preferred use of the platform. Maintaining Grasha's nomenclature according to the most pronounced stereotype in a pattern, these students consisted of 38% "avoidant" user type, 27% "collaborative/participant", and 10% "competitive" usage pattern. A single platform will not cover any mixed group of students and configurable views need to be considered in future.

1 INTRODUCTION

This paper is the fourth in a series of publications about the results of gamifying a course in Software Engineering. The gamified version of the course exposed issues with difficulties in self-regulated learning in students and an important dissonance between the seriousness of study and the perceived inappropriateness of comparing it with a "game" (Berkling et al., 2013b). Following this, a detailed study of the mismatch in motivation between students in a restricted ecosystem (namely grades and passing) and assumed universal motivators like autonomy, mastery and purpose (Pink, 2010) was explored in detail (Berkling et al., 2013a). Results show that scaffolding and a simple work environment suitable to cover a large spread in students' needs was important. Based on these experiences, a third publication (Thomas et al., 2013) explored theoretical solutions in more detail relating tool capabilities to learner types that seemed to match most closely with the student profiles encountered in past courses. This work was done jointly with a Bachelor student at the University and thus allowed for insights from student body blending into the resulting work. In this publication, the choice of Coursesites (an e-Learning platform provided by Blackboard) is explained in detail. In summary, the platform supports group work, grade overview, content sharing, forum, group spaces, and collaborative aspects. These functionalities were important criteria for the choice of platform in order to support the goal of creating autonomous students who pursue mastery and purpose in their learning. Having a tool that supports scaffolding for this path towards self-regulation was a key outcome of our previous work in this area. Coursesites is used with this end in mind, providing a plethora of functionality to be used, while not expecting all students to use these equally. This publication extends the previous work by looking at how students have been using the functionality provided by Coursesites in order to verify the existence of subgroups of users that use the platform in different ways. A student survey was conducted for 77 students currently engaged in the class to study which features of the platform are most used and whether there exist any patterns in usage for any definable subgroups.

The paper is structured as follows. After a review of the theoretical foundations for this work in Section 2, Section 3 will explain the design of the survey. Section 4 will discuss results that show how functionality usage can describe groups of student learner types. Section 5 offers a brief discussion on how various platforms might then fit to student learner types, followed by a discussion and future work section.

2 THEORETICAL FOUNDATION

The software engineering course was redesigned around motivators with content and platforms aligned as shown to be important (Derntl, 2005). For example, if self-regulation and autonomy is an important learning outcome then an e-platform can support this goal by providing a team-based to-do list or the possibility to advance through topics at personal speed. If mastery is important then multiple submissions could be allowed along with an up-to-date view of current grade. If scaffolding is needed, the progressive unlock of content can be enabled. The content must match the level of the student and the tasks designed to allow students independent work that can be shared if collaboration is important to the student. For competitive learners performance is important and the platform can provide class average grade for each assignment. All these dimensions were explored in detail in previous publications and led to the usage of an extensive e-platform to support this kind of teaching environment for different kinds of learners. Learner types and the chosen platform are briefly reviewed here for context of the current study.

2.1 Learner Types

According to Susan A. Santo (Santo, 2006), there is no generally accepted definition for learning styles despite the fact that many different learning style models exist. For the purpose of this paper, Grasha's definition of a learning style as somebody's preferred way of learning (Grasha 1994; Fuhrman 1983) is sufficient because they are used as stereotypes for a first approximation in an iterative approach to understanding subgroups of students' usage of platform functionality. According to the Grasha-Riechmann Student Learning Style Scales, there are six styles that can be differentiated amongst learners as given in Table 1. For the purpose of this work, these profiles represent theoretical stereotypes; based on their description, we will define characteristic platform usage profiles. The usefulness of such profiles will be validated if they prove helpful as an intermediary step in defining homogeneous subgroups of user profiles with respect to how the e-platform is used by this subgroup.

Table 1: Learner Types.

The **participant** learner is very interested in the course content and asks questions.
The **avoidant** learner works as little as possible or only shortly before a dead-line.
The **independent** learner works on his/her own and rarely asks for help.
The **dependent** learner needs lots of support and detailed instruction.
The **collaborative** learner prefers working in a team.
The **competitive** learner wants to do better than other course participants.

We use Grasha's theoretical definition of six learner-stereotypes to derive an exaggerated e-platform usage pattern for each. Because students do not match stereotypes, usage patterns become evident in the degree to which a student matches a combination of these pure definitions. If common manifestations exist, then the student body can be described in such terms as subgroups.

2.2 Learning Platform

To enable a blended classroom of more than 70 students with technology, various platforms were considered. In (Thomas et al., 2013) three online learning platforms were evaluated for our purpose based on developed guidelines that supported learning styles and adequate functionality. At the time, CourseSites offered the best choices to implement Software Engineering as a flipped classroom, with the deciding factor towards its ability to have a team space. For the Fall 2013 class, a course was created on this platform using various features. Key to choosing a tool is to reassure that it supports the design criteria and necessary processes in the classroom explained in more detail in previous publications. In that sense, CourseSites is replaceable by any other MOOC (Massive Open Online Course) platform that supports the needed functions. The hypothesis at the time was that students will use the tool in different manner according to their learning style. In this paper students were asked to rate the functionality. If the hypothesis holds true, then students should fall into categories based on their use of the functionality. For this purpose, a survey was conducted asking students about their opinion on the importance of the spectrum of functionalities. This survey is explained next.

3 STUDENT SURVEY

After using coursesites for 6-7 weeks, students where queried on the importance of certain functionality groups of their learning platform. While students have had limited experience with the platform at hand, students have been using Moodle for a long time, including high school. Some students have taken MOOCs but all of them have experience with any number of online social communities. From this point of view, they were asked to evaluate not the platform or its content but the functionalities it offers, assuming that the functionality was implemented well. Evaluation was based on a four point Likert scale from "totally irrelevant" to "very important". In addition, the possibility for "other" or "don't know" was allowed. 77 computer science students currently enrolled in the course answered the survey during class time.

3.1 Functionality Groups

In order to ask students about all functionalities, the various aspects of any platform were listed according to the possible dimensions as shown below – the complete list is given in Appendix A:

- Content dimension: self-made, peer-made, professionally made, static, dynamic, personalized, logical content, illogical content, mixed content.
- Time dimension: synchronous (classic course), asynchronous (on demand/on progress), mixed
- Grading dimension: grades based on: forum entries, likes, homeworks, peer-grading, autograding, self-grading, multiple attempts, accumulating grades
- Leaderboards: Grades, top likes, top activity,..
- Social dimension: single player, multi-player (community), choice, friends only, … cohorts (grouping students e.g. by hand-in time)
- "Living" spaces (scope): Global (Forum), Team (Journal, blog, ..), Personal (Journal, Blog....) , Private
- Communication features: Life chat, forum (asynchronous), likes, ratings, comments,
- Learning path: multiple, single, dynamic, static
- Progressive platform view: onboarding, scaffolding of platform functionality, elder role

3.2 Functionalities According to Learner Type

Learner types listed in Section 2.1 are used as stereotypes for the purpose of this work. In this sense, we can define a simple prototypical but different use of the platform for each of the stereotypes along the dimensionalities described in Section 3.1. Tables 2-7 define the functionalities according to the learner type characteristics. The highlighted parts are especially important to that learner type. The functionality listed is taken from Appendix A. For example "Simple Platform View" relates to the dimension of Progressive Platform View and is important to the "Avoidant" user who likes to keep it simple. "Benefits from Forum" relates to the Communication Dimension. In this sense, these tables do not depict derived characteristics but definitions to describe stereotypical dimensionality of the hypothetical learner type. The usefulness of these definitions will be verified only if they serve as an intermediary form of describing actual usage patterns by real students.

Table 2 shows the functions that we define as important for the avoidant learner. This stereotype is different from others as the goal is to manage the course with as little effort as possible. A passing grade is the goal. All has to be kept as simple and clear as possible. Team based effort is essential.

Table 2: Important Features for Avoidant Learner.

	Function (important in bold)
Avoidant: "Keep it simple, passing is everything!"	**Simple Platform View**
	Lots of support for using platform
	Benefits from Forum
	Benefits from publicly posted Homework
	Wants to keep an overview of current grade to make sure it is a passing grade.
	Likes to know how much work is left
	Prefers multiple attempts in an online exam
	Team projects are essential for survival
	Team grading is essential
	Teacher should provide clear learning path that does not change dynamically
	Benefits from peers' work
	All course content should be easy to find and clearly marked as necessary.

Table 3 shows the functions that we define to be important to a collaborative learner. That stereotype is defined by the wish to work in a community. Synchronous learning is more important than independent learning. Grades are important. Work load and a good chance at a good grade through formative grading are relevant. Simple is good here as well. The prototypical collaborative learner is not interested in individual grades and projects.

Table 3: Important Features for Collaborative Learner.

	Function (important in bold)
Collaborative: "I can do it in a team!"	**Synchronous learning**
	Lots of support for using platform
	Forum and team blog and journal, team-based todo list
	Share Homework
	View current grade
	Peer evaluation
	Likes to know how much work is left
	Prefers multiple attempts in an online exam
	Formative grading
	Team grading
	Choose my own team
	Classroom interaction and peer content
	All course content and Dashboard with news

Table 4 shows the functions that we define as important to the competitive learner. The stereotype is defined by the wish to be the best. Leaderboards, likes, badges, grades, view of class performance are very important. Multiple attempts in exams serve the purpose to gain full points on an exam. This person wants to see all the information on the system – progressive unlocks would hinder the performance. Team work and projects can slow this person down. Asynchronous learning is important so that this learner can move on to the peer group at the next level when ready (as in sports or games) and not be stuck with the same cohort (like the traditional classroom setting).

Table 4: Important Features for Competitive Learner.

	Function (important in bold)
Competitive: " Challenge me!"	Synchronous/asynchronous learning ok
	Doesn't need or even want progressive unlocks
	Team & personal blog
	Leaderboards
	Grades and Class-performance
	Achievements
	Top Likes, Ratings, Activities
	Homework with peer and self-evaluation
	Multiple attempts in exams
	Formative Grading
	Likes, Ratings
	Comments on homework
	Self-made dynamic content
	Course overview and static content

Table 5 shows the functions that we define as important to the independent learner. The stereotype is defined by the wish to work alone. Asynchronous learning is important. Individual projects are essential. This learner type prefers to create their own learning path and not just rely on the teacher.

Table 6 shows the functions we define as important to the dependent learner. This person needs strong guidance. Flexible learning path or changes in content are not appreciated. Teamwork is preferred over individual work. Synchronous learning, defined, regular homework is important. Grade overview is helpful. Course content has to be easy to find and clearly structured.

Table 5: Important Features for Independent Learner.

	Function (important in bold)
Independent: "I am working by myself"	Choosing own speed of learning
	Progressive unlocks or **give me everything from the start**
	Grades
	Improvement with respect to self
	How much work is left
	Homework
	Multiple attempts and formative grading
	Individual grade
	Individual study
	Self-chosen team
	Individual projects
	Comments on work
	Multiple learning paths according to own needs
	Self- and peer made content
	Extra helpful information

Table 6: Important Features for Dependent Learner.

	Function (important in bold)
Dependent: "I'll never make it on my own!"	**Synchronous learning**
	Very simple view of platform
	Team blog, Team-based todo list
	Team-based
	Grades to see if they are surviving
	How much work is left
	Homework based grading
	Multiple attempts in exam, formative grading
	Team work
	Comments on work
	Single, well defined path
	Professional static content
	Course material easy to locate

Table 7: Important Features for Participant Learner.

	Function (important in bold)
Participant: "I'm really interested!"	Mix of synchronous/asynchronous learning
	Forum, blogs, journals
	Sharing of homework
	Grades
	How much work is left
	Homework based grading
	Multiple attempts in exam, formative grading
	Mix of individual/team work
	Comments on work and ratings
	Ratings, likes
	Classroom interaction
	Self-made, peer-made and professional content

Table 7 shows the functions that we define as important for the stereotype of the participant learner. This person will be open to try out various functions. None are of particular importance, but all can be tested. If the teacher recommends the function then this person will try out how to integrate it into their study.

Student responses were collected via

Surveymonkey and the Likert scales were weighted with the various user types to display student profiles. Results from the survey are presented in the next section.

4 SURVEY RESULTS

For each of the functions listed in Appendix A, 77 students' responses on the 4-point Likert scale from "totally irrelevant" to "very important" were collected.

4.1 Learner Type Vector

For each of the learner types a weighting vector was created for the functions and the dot product with the responses collected. This resulted in a vector of length 7 denoting a mix of learner types that can then present the foundation for categorizing students accordingly. The calculation is given in Equation 1:

$$S[t] = \frac{\sum_{i=1}^{n} L[student][i] * W[t][i]}{\sum_{i=1}^{n} abs(W[t][i])} \quad (1)$$

Here, t is the learner type, n is the number of functions evaluated (i corresponds to the question #), L is the Likert scale from 0..4 ("totally irrelevant"…"very important"), W is the weighted vector of how important a functionality is for a particular stereotype, with values 0 (not relevant,-1 (not important), 1 (important), and 2 (very important). Each student response is then represented by the vector $\vec{S}$ of length 7, where the average over all students for each element is subtracted from Equation 1 as shown in Equation 2 to focus on the difference.

$$S[t] - \overline{S[t]} \quad (2)$$

The results are then plotted for each student and compared by inspection.

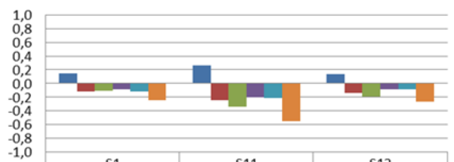
4.2 Student Vector-groups

It can be seen by inspection that certain vectors $\vec{S}$ look similar across students. Figure 1shows some of these for 14 sample student vectors.

Similarities between different student vectors can be noted. Comparing S1, S11 and S13, it can be seen that the basic pattern, with different magnitudes shows a learner type that is more avoidant than average and classifies less than average as any of the other types, especially concerning collaboration, competitiveness and participation. In contrast, S2, S4, S12, and S14 are less avoidant than average (to different degrees) and stronger than average on collaboration, competitiveness and participant characteristics. S3, S6, S7, and S8 show average profiles. Going through the data by inspection, the following patterns can be found:

- 0: Average (12)
- PC: Participant and Collaborative (4)
- PCA: Participant, Collaborative, Avoidant (1)
- PC-A: Participant, Collaborative and not Avoidant (14)
- PC-I: Participant, Collaborative and not Independent (1)
- CompP-A: Competitive, Participant and not Avoidant. (8)
- A: Avoidant (4)
- Ax-P: Very Avoidant and not Participant (12)
- I-D: Independent and not Dependent (1)
- A-PC: Avoidant and not Participant and not Collaborative (11)
- A-CompP: Avoidant and not Competitive and not Participant (2)
- 0-PC: Not Participant and not Collaborative (2)
- P: Participant (1)
- 0-AI: Not avoidant and not independent (1)
- D-P: Dependent and not Participant (1)
- DP: Dependent and Participant (1)
- Minus-all: All score low (1)

Maintaining Grasha's nomenclature according to the most pronounced stereotype in a pattern, categories can be collapsed into **Avoidant** (A,Ax-P, A-PC, A-CompP), **Participant&Collaborative** (PC, PCA, PC-A, PC-I, P, DP), **Competitive** (CompP-A) and Average (0), the pie chart in Figure 2 shows the fragmented, yet categorized distribution of the student body.



	S1	S11	S13
avoidant	0,2	0,3	0,1
collaborative	-0,1	-0,2	-0,1
competitive	-0,1	-0,3	-0,2
independent	-0,1	-0,2	-0,1
dependent	-0,1	-0,2	-0,1
participant	-0,2	-0,6	-0,3

Figure 1: Vector *S* for student S1, S11, S13: more avoidant than average, less than average on other characteristics.

4.3 Platform Requirements

Stereotyping the platform most coveted by each of

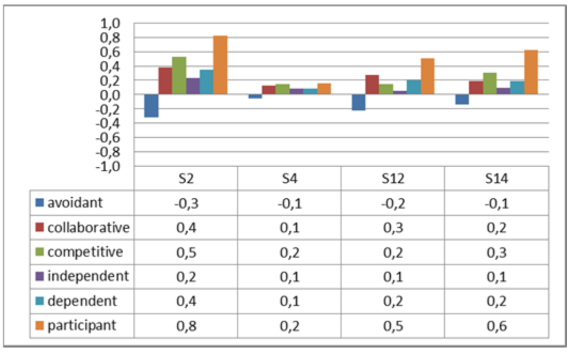


Figure 2: Vector *S* for students S2, S4, S12 and S14: less avoidant than average, more than average on other characteristics.

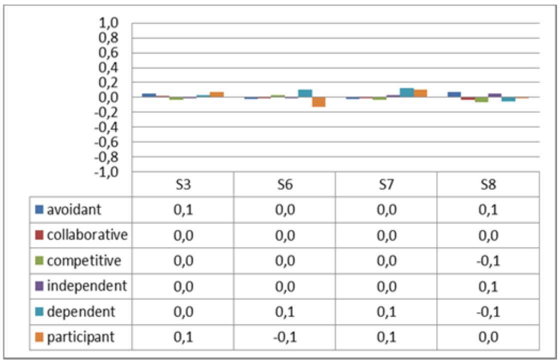


Figure 3: Vector *S* for student S3, S5, S7, and S8: average students.

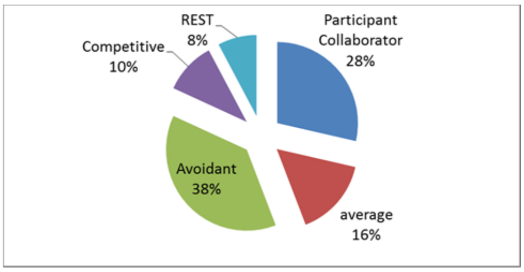


Figure 4: Fragmented Student Body.

the larger groups of students, it can be seen in Table 8 that the functionalities are quite different.

Clearly, with a fragmented student body as shown above, a platform would have to be configurable in at least three diagonally opposed ways for **Avoiders**, **Competitors** and **Participant Collaborator** groupings. However, compared to frontal lecture without any flexibility, technology that is configurable by the student may provide more opportunity to render learner dependent views in the same classroom.

Table 8: Important Features for Main Learner Groups as shown in Figure 2.

Functionality	Avoid.	Part.Coll.	Competitive
Time Dimension	synchr.	synchr.	asynchr.
Progressive View	simple		all
Living Space		team view	
Progress Overview	grades	grades	Point, Badges, Levels
Grading Dimension	team	team, peer-grading	individual, leaderboards
Social Dimension	team	Self-chosen team	individual
Communication		forum	likes, ratings
Learning Path	simple	adaptive	open
Content Dimension	given	peer	self, peer

5 PROFILES VS. PLATFORMS

Coursesites, which was chosen for this course, can also be used as a MOOC platform. There are a number of MOOC platforms in use currently and it is interesting to look at their functionalities given the current study. As MOOC platforms are all under development, it would be difficult to define how each provides functionality within the nine dimensions given in Appendix A. In addition, courses on these platforms have various ways in which they can be configured and designed. Still, there are some basic features that may or may not be available on particular platforms. NovoEd, EDX and Coursera are chosen examples of MOOC platforms because they represent some of the most popular platforms, in addition, Duolingo is an example of a popular freely available language learning platform. While NovoEd has the capability to provide team and personal “living spaces”, EDX has the capability to show an excellent progress bar but difficulty with clear Forum spaces. While Coursera makes it easy, according to student reports to find the learning path, EDX may feel a bit more difficult for onboarding. Table 9 indicates the current particularities of the platforms based on courses visited by the author in 2012. Only **distinguishing features** are listed to keep the table simple. Such particularities may influence which type of student would prefer a particular kind of platform. It is of interest to note, that none of the platforms allow the students to configure their own view.

Given the exemplary particularities as shown in Table 9, the **Avoidant** learner group will be more comfortable in a synchronous course with an easy view of the platform functionalities and content, team based effort and a clear view of the current grade. Such a student would need the simple view from Coursera, the grade progress view from EdX and the team based approach that NovoEd supports very strongly.

The group **Participant Collaborator** is probably best served with the NovoEd platform because it provides good collaborative spaces and enough information about the grades and progress to grant the basic overview needed by this group.

The **Competitive** group will find some of these platforms constraining in that they are mostly set up to be synchronous with single given path. A tool like Duolingo that allows choices of path and speed as well as leaderboard, points and badges may be more suitable. However, the team dimension is completely missing to support the competition aspect with others. This learner type will also not be served well by any one of these platforms yet.

Table 9: Features provided by MOOCs highlighting particularities.

MOOC	TD	PV	LS	PO	GD	SD	CF	LP	CD
Edx	s			y					
Coursera	s	s		p					
Novoed	s		f t i	p	i,t s		l, p		
Blackboard	s/a		t	p					
Moodle	s/a								
Duolingo	a	cU fU	i	y	a, p m			m	nl

Table 10: Key to Table 9.

TD: Time dimension: s=synchronous, a=asynchronous
PV: Progressive Platform View: s=simple, cA=content all, cU=content unlock fA=features all, fU=features unlock
LS: Living Space: n=none, f=forum, t=team, p=personal
PO: Progress Overview: y=yes, n=no, p=partial
GD: Grading Dimension: n=none, a=automated, s=self, p=peer; i=individual, t=team; m=multiple attempts, 1=single attempt
SD: Social Dimension: i=individual, t=team, m=mixed, a=all
CF: Communication Features: f=forum, ch=chat, m=messaging, cc=teacher comments on work, l=leaderboard projects, p=personal interactions
LP: Learning Path: s=single, m=multiple, d=dynamic
CD: Content Dimension: s=self made, p=peer made, t=teacher made, d=dashboard, x=extra info, nl=no lessons

While the match between student learner types and platform offerings has not been done in a quantitative manner, the discussion serves as input to understanding student retention and how platforms can cater to various needs.

6 DISCUSSION

In this paper, it was shown that student population can be grouped by learner-type vectors that are related to functionalities on learning platforms, which have been grouped into a nine dimensional feature space. We use Grasha's theoretical definition of six learner-stereotypes to define an exaggerated usage pattern for each. While students do not match these stereotypes, usage patterns become evident in the degree to which they match a combination of these pure definitions. As learners are not stereotypical, such vectors are a better means of grouping students. It was shown that such grouping is possible and that opposing dimensions of functionalities are required for different user groups. This finding, hereby quantified, can have a direct consequence on understanding how well students are able to learn in different environments, virtual or real. Will environments need to be specialized or adaptive to enable optimal learning for each student? Further work is required to refine understanding of these groupings and define user-based views for a single course offering. Open questions are whether platforms should cater to particular learner types? How does this affect teaching in the classroom at University where classes are usually not split by learner types? Splitting classroom by types would make life for the Avoidant type quite difficult. Some research will have to go into how to provide different front ends to the same material.

ACKNOWLEDGEMENTS

The authors would like to thank conversations with students who participated in the survey and were part of the new way of teaching.

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APPENDIX A

The following table lists all functionalities according to the 9 questions from Section 2.2 on which the student survey is based.

Table 11.

Time Dimension
TD: Synchronous learning
TD: Asynchronous learning
TD: Mixed style
TD: Choosing your own speed of learning
Progressive Platform View
PV: A very simple view in the beginning that opens up progressively
PV: A lot of support with the platform in the beginning
PV: Gaining more rights as I work more with the platform
PV: Give me everything from the start – I can handle it
Living Spaces
LS: Forum for all (public)
LS: Team blog (public)
LS: Personal blog (public)
LS: Team journal (private to team)
LS: Personal journal (private to me)
LS: Sharing homework hand-ins for others to see
LS: Team-based Todo Lists
Progress Overview
PO: Leaderboard (Points)
PO: My Grades (overview)
PO: Average Grade in class
PO: improvement wrt. self
PO: Achievements (badges)
PO: Top Likes
PO: Top Activity
PO: how much work is left

Table 11. (cont.)

Grading Dimension
GD: Forum entries GD: "likes" of your contributions by others GD: Homework GD: Peer evaluation GD: Self evaluation GD: Multiple Attempts in evaluation GD: Accumulated formative grading GD: team based grade GD: individual grade GD: mix of team/individual grade
Social Dimension
SD: Study on your own SD: Study in community SD: study in self chosen team SD: study in random team SD: change choice of who you study with SD :team projects SD: individual projects SD: mixed team/ind. Work
Communication Features
CF: Life Chat CF: Forum (asynchronous) CF: Likes (cool) CF: Ratings (1-5) CF: Comments on your work CF: Leaderboards CF: Classroom interaction – person2person CF: Team meetings when you decide (rather than in class with teacher present)
Learning Path
LP: Choice of multiple learning paths to choose from according to my own needs and preferences LP: A single, well defined path prescribed by the instructor LP: A path that changes depending on my needs or progress LP: A static path so that you have a defined amount to learn and a defined end in time to the learning LP: Personal Todo Lists
Content Dimension
CD : Self-made content CD: Peer-made content CD: Professional content CD: Static content CD: Dynamic content CD: Syllabus/Course Introduction CD: Info about teacher CD: Home-page/Dashboard with News, Updates… CD: Course content (slides, assignments, test) CD: Extra Information (going beyond class material)

Making Classroom Response Systems More Social

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Keywords: Classroom Response Systems, CRS, Live Feedback, Social Learning, Social Communication, Class-wide Discussion.

Abstract: Classroom Response Systems (CRS) have been used in the last years to support teachers getting feedback from their students, especially in lessons with large audiences. Whereas CRS become more and more popular it is less known how students really use CRS for providing feedback and if social communication on CRS - and as a consequence in the classroom itself - can increase the benefit of CRS. Our research aims to open the discussion for more social communication on courses and lessons on CRS-usage by providing grounding of social communication with CRS. Moreover we outline conceptual and technical insights on an Social CRS implementation.

1 INTRODUCTION

It is a commonplace that learning success highly depends on the social embedding of learning processes. Beside motivational or emotional aspects we want to emphasize, that this embedment can be defined in terms of communicative interventions into learning processes. Social embedment of learning allows any learner to evaluate his or her understanding of given contents. It even allows to assess the appropriateness of this understanding through communication with other learners as well as with teachers and tutorial attendants in different learning contexts. Additionally it is another commonplace that academic teaching still often shows a lack of socially embedded learning this way. Even more, academic teaching misses significant strategies to develop this aspect of learning (Laurillard, 2002) (Laurillard, 2012). However, the issue of how to overcome this state and enable a significant social involvement of learning is far less trivial and still a serious challenge on quality and success of learning (Masschelein and Simons, 2013).

Classroom Response Systems (CRS) can be regarded as a technological reply to this issue. Whereas the original idea of CRS mainly implements a clicker functionality, where students answer multiple choice questions of the teachers (Fies and Marshall, 2006), they now become a wider platform to provide feedback and to elaborate it in direction to a higher social embedment of learning. Although teachers are still able to ask multiple choice questions, modern CRS provide students with the possibility to give more detailed feedback on demand (Feiten et al., 2012) (Kundisch et al., 2012).

Whilst modern CRS have been extended with many features, we think that CRS currently do not draw on their full potential to support the social embedment of learning. Until know, they are a helpful tool to link more explicitly the presentation and transmission of content on the teachers side with a specific range of receptive reactions on the learners side. In result CRS may support the addressing and solving of understanding problems.

Moreover, experience with CRS with features beyond mere multiple choice tests resulted in participants spontaneously inventing new forms of communication. For example, a public chat-like feedback channel intended originally to pose questions to the teacher was used for tutorial-style communication and for organizing study groups by the students. This demonstrates a demand for increased social interaction in the classroom.

But at this stage of evolution especially social interactions and communication are neither usefully inclosed by CRS learning concepts nor documented for students and teachers further usage on the CRS. In previous work, we recognized a strong need of students to communicate with each other on CRS and to get durable access to the CRS content generated in a lesson (Vetterick et al., 2014).

Although the social evolution of CRS seems to be a vital demand as well as an exciting direction of development, the relation between social interaction and learning is widely unexplained, especially in the context of blended and e-learning interventions. This conceptual paper shall explore this gap in order to better estimate social phenomena in the evaluation of existing CRS and to provide significant constraints for technological advancements.

This publication describes our position on a current learning model, which covers latest and coming generations of CRS that are aware of social communication and interaction between students and teachers. Based on this discussion we will elaborate which aspects of socially embedded learning CRS currently enable and which aspects are still to be claimed. Furthermore this work outlines how coming CRS should look and act in order to contribute a serious intervention into the social challenge on learning.

The rest of the paper is organized as follows. Section 2 covers the related work in the field of learning and feedback and in the field of CRS. In section 3 we show that there are two different types of communication on providing feedback. Section 4 presents our approach for an Social CRS that is aware of and supports these types. At the end we conclude our work and outlook future research in section 5.

2 STATE OF THE ART

2.1 Learning and Communication/Feedback

To ground our investigation on the social embedment of learning, we want to adopt (this chapter) and partially develop (chapter 3) the learning model, Diana Laurillard introduced in the late 1990s and has refined up to her present contributions to the debate on academic teaching. It promotes our position in a threefold way (Laurillard, 1999) (Laurillard, 2002) (Laurillard, 2008) (Laurillard, 2012).

- First, it comes from scientifically based efforts for reforms in academic education.
- Second, it uses an educational-driven approach to the use of digital technologies (Laurillard, 2008, p. 1).
- And third, it implements important aspects of the social nature of learning.

Her model essentially consists of three layers composed to an conversational framework of learning (Figure 1). These layers postulate the main functions teachers and learners have in educational settings. The first layer, the layer of conceptual discussion combines the function of content distribution on the basis of theoretical conceptions on the teachers side and the function of content documentation framed by an individual conception on the learners side. Learners even have to reply on distributed content and to control their individual understanding of content in the light of the teachers reactions on their replies.

The second layer, the layer of interaction, is determined by a learning environment constituted by the teacher. Within this environment learners are obligated to solve concrete tasks, such as working out exercises, solving questions or preparing talks or papers. Interaction even includes to observe how learners cope with those tasks on the teachers side. Additionally, learners will admit their processing of tasks while teachers attend to and react on their attempts at a solution.

The third layer establishes a connection between the first and the second one. It has a meta-cognitive function and its realization allows to adopt the operations on the interactive layer with respect to the interchange of content on the conceptual layer. Furthermore it enables to assess the reaches and limits of theoretical concepts in the light of task coping and outcomes as practical experiences on the interactive layer.

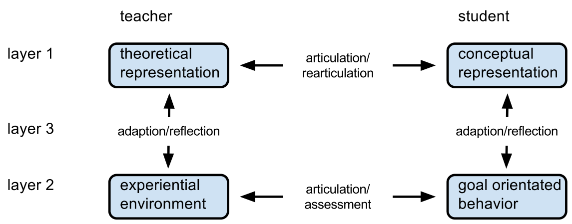

Figure 1: Conversational framework of learning (Laurillard, 1999) (Laurillard, 2002) (Laurillard, 2012).

Laurillard claims that learning processes based on these three layers go beyond simple instruction. Because any successful understanding of content depends on the ability of teachers and learners to apply a common ontological (object reference) and epistemic (direction of understanding) frame of reference. That means they have to anticipate a common identification of objects and their epistemic treatment in order to use transmitted content the same way. However, a central demand on teaching is not to presume this redundancy of orientation between teachers and learners, but to support its evolution. This evolutionary process has to take into account an iterative progress of adjustment between the differing prerequisites of the participants in an educational process. The core instrument Laurillard suggests to make the outlined adjustment run is giving and handling feedback on each of the frameworks layers.

First of all, feedback is a way to interrupt the progress of content transmission and task instruction in order to claim a sequence of adjustment between transmission and reception of content. Normally this is the case when intentions behind content transmission on the teachers side and abilities to cope with content in the intended way on the learners side do not interlock. Any reaction on feedback has to respond to that imbalance between intended and performed understanding more or less extensively. The core issue to compensate this imbalance will be to explore the individual conditions learners apply to understand given educational content. This is a common sense affordance on modern teaching and it means to center teaching around the learner and provide as much occasions as possible to clear up and integrate the learners prerequisites within learning processes.

Enabling feedback belongs to a set of ideal solutions to integrate modern, learner centered teaching into academic education (Weimer, 2013). But there is a common risk behind those avant-garde demands on teaching. Admitting feedback contains the problem to include topics and issues into the learning setting that could endanger the viability of courses and lectures. Not only genuine spam but also content driven feedback is able to disturb a lesson significantly. It is an important challenge to distinguish between feedback assimilable to a lesson and feedback that cannot be integrated. Beside explicit rules or technical filtering, we assume that those decisions are normally processed by the use of communicative strategies.

2.2 Modern Classroom Response Systems

As Kay et al stated in (Kay and LeSage, 2009) CRS have been voting mechanism in the first place: Teachers ask a multiple choice question and students could answer by clicking the corresponding button on a special voting device. As these voting devices are very expensive and have to be maintained, modern CRS use the mobile devices students already have. Since mobile devices, as smartphones, pads or notebooks, provide a display that can draw more than just buttons for multiple choice questions, CRS evolve to comprehensive feedback systems that are able to implement more complex forms of feedback (Draper et al., 2002) (Feiten et al., 2012) (Jenkins, 2007) (Kundisch et al., 2012) (Vetterick et al., 2013) such as:

- Multiple Choice questions asked by the teachers (TQ): Teachers can still use modern CRS as clickers, but without the limitations of a hardware device, so they may label their answers or use a flexible number of answers for example.
- Questions from students (SQ): Students ask specific questions. Other students may vote questions up or down, which can be an indicator for the importance of questions. Based on the number of votes the instructor can address the issues in his lecture. In a variant of this scheme, members of the audience may reply in writing using the system.
- Rating specific presentation parameters (SP): Students mark specific issues, for example when the instructor is moving ahead too fast or the talking volume is inadequate.

Moreover modern CRS are able to organize the given feedback to get a deeper understanding. The following methods present current methods for organizing live feedback.

- Durable Access (DA): Students and teachers can later access all the given feedback. Teachers are then able to provide additional material or examples and can improve the presentation. Students can use the feedback to identify important facts, topic or issues for a better preparation for their exams (Crouch and Mazur, 2001) (Vetterick et al., 2014).
- Identify students learning issues across lessons and terms (LA): By the use of identities (or even pseudonyms) teachers are able to track down how students learn. Interested readers are referred to the field of learning analytics (Ferguson, 2012).

Figure 2 demonstrates how the three forms of feedback TQ, SQ and SP are organized by DA and LA. Whilst the feedback generated in a lesson can be accessed afterwards (DA), LA allows to identify correlations between the students feedback over lessons or terms.

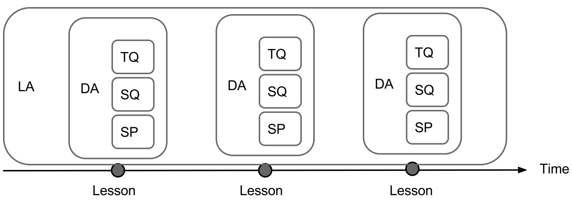

Figure 2: Interaction of access modes and CRS-features.

Regarding the previously presented interdependent layers of learning process organization (discussion layer, interaction layer, layer of adoption and reflection), modern CRS only fit these layers in parts. The layer of discussion is covered by students questions (SQ) and the possibility to rate teachers speech parameters (SP). Students initiate the discussion about a certain issue or parameter, whereas teachers have to respond. The layer of interaction is covered by students questions (SQ), where students again initiate the feedback by asking questions. Additionally the layer of interaction is partly covered by teachers questions (TQ), because teachers demand feedback from their students, who then have to interact with their teachers. The layer of adaption and reflection is partly used by all modern CRS implementations of TQ, SQ and SP: Students may reflect their knowledge and understanding on teachers (TQ) or other students questions (SQ). Moreover teachers may reflect their teaching to identify facts, topics or illustrations that are hard to understand for students (issue repeat offender).

Regarding the methods to organize feedback, LA and DA cover the layer of adaption and reflection, too. DA provides persistent access to the content created by teachers and students during a lesson, so students are able to reflect their knowledge and understanding afterwards at any time. Furthermore teachers can do the same to reflect their teaching. LA allows teachers to get a deeper knowledge of how students proceed in their lessons over time (for a whole term for example), so teachers can reflect their teaching on a wider scope.

3 COMMUNICATIVE LEARNING

3.1 From Feedback to Communication

Chapter two showed that feedback is no add-on but a core element of learning. Here we want to add that feedback only works in connection with social, or rather communicative forms of intervention into the learning process. Therefore, any elaboration of feedback depends on the specific communicative strategies the participants of learning processes are able and allowed to realize in educational settings. What these strategies might be, how they work and to what extent they support learning processes are open questions within the learning research discussion we presented above. We consider answers to these questions to be a significant prerequisite for the evolution of feedback technologies like CRS.

Communication takes its special role within feedback processes, because its main function is not to discover the full potential of an individuals conditions applied to his or her engagement with transmitted content. That means, communication is more than just talking about individual states or sensitivities within learning processes. Communication has to find a scope of selective topics and issues, which the communicative partners are able to connect with from their individual state while they are attending to and coping with feedback. To treat feedback by communication means to find a selective way of marking and negotiating feedback. Selective communicative treatment gives feedback a specific sense and determines its relevance. We now want to distinguish two major strategies conveying two basic forms of coping with feedback in the outlined way (for general introduction (Baecker, 2009)).

3.2 Systemic Feedback/Communicative Strategies within Lectures

Lectures normally work on the conceptual layer of learning. Lectures are successful when learners are able to anticipate an intended conceptual order of knowledge out of the way they document presented content (Figure 3). From a communication theory point of view, this setting could be regarded as systemic setting. Communicative Systems contain an affordance-competence balance (Baecker, 2010). And this is the case, when behavior on the one hand could be regarded as an accomplishment of an affordance setting on the other. The learners activities to document content and to anticipate underlying conceptual orders then are accomplishments to the intentions a teacher has in a specific learning process. Feedback framed by a systemic communication strategy will focus the partners on their knowledge about the structure of demands within that setting. They have to specify and reformulate what they determine to be the right understanding of underlying affordances.

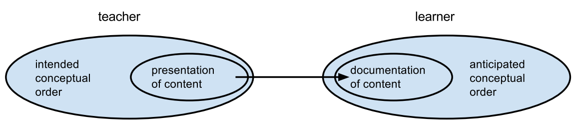

Figure 3: Conceptual basis of learning based on (Laurillard, 2002) (Laurillard, 2012).

In result the partners are able to decide whether their behavior is a deviation reclaimable by an accomplishment that fits to their understanding of given demands. Reaction on feedback within this framework will take feedback as a hint on deviation from ideal and it will reclaim this ideal by re-defining the affordance structure behavior should apply to. The problem is, such communicative framework only deals with feedback allowing to connect deviating behavior with redefinitions of given affordances. That means, feedback already has to contain certain links to that affordance structure. In other words, it has to be consciously settled within a given affordance framework, which is shared between the communicative partners in the feedback process.

For example students ask for more explanation within a given topic area because they understand this topic area to be important for their exams and fear to overlook important issues without more explanation. However requesting more explanation could be a deviation from ideal learner performance within a lecture. But it could be handled within the systemic strategy, if the students request already contains knowledge about an intended affordance on the teachers side, e.g. exam preparation, and if this knowledge is shared between teacher and student. Replies to this feedback only have to redefine the affordance structure exam preparation in order to adjust performed and ideal behavior, that means to decide whether requesting more explanation is useful or not within the affordance set exam preparation.

We call feedback annotated in Figure 4 affordance competent or systemic feedback. We want to suggest that it only can be given by skilled students with enough experience within specific educational settings as university lectures or courses. It only works if feedback is applied to students assumptions on possible affordance structures or more general if feedback can be treated this way. Treating feedback within a systemic strategy needs communicative partners, who are able to find and assume comparable assumptions on a set of affordances in a learning process.

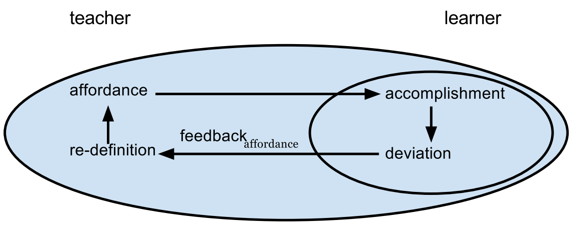

Figure 4: Systemic feedback process (integrated application of (Baecker, 2010) and (Laurillard, 2002)).

3.3 Concept Critical Interventions into Feedback

Feedback without a strong linkage to socially shared affordances is difficult to handle within a systemic framework. This is a significant problem for learning processes. Because this more open type of feedback contains the highest potential to enable and develop learning advancements (Bateson, 2000). Because deviation from pre-defined sets of learning affordances allows to go beyond affordance sets and to understand their constitution and justification within broader conceptual considerations (Baecker, 2008) (Baecker, 2012) (White, 2012). If we go back to our little example of exam preparation it makes a significant difference whether students understand how to apply lecture contents to exam affordances or they understand, that exam affordances are constituted in the context of different and sometimes even competing standards within scientific paradigms or even other perhaps administrative and legal considerations. Feedback that deviates from pre-defined affordance sets contains the opportunity to investigate such contexts and to reclaim a deeper understanding of learning affordances and their range of variation .

The learning theory discussion above suggested to realize such demands by switching between different learning layers and to transfer experiences on one layer to the other. It has been emphasized that such transfer allows to insert experiences on one layer as a hint on the conceptual basis, that constitutes the other layer. For example the quizzes function of CRS can be used to go through a kind of exam like situation in order to help students anticipating the exam affordance set behind lectures. However the main issue here is, that this conclusion has to be worked out in a broader communicative setting. Within this setting communication has to ensure, that deviations are not rejected too soon as interferences into pre-defined systemic frameworks. Instead communication has to be aligned to find contexts which handle systemically deviating feedback as occasion to search for other affordance-accomplishment balances or as occasion to adapt pre-defined affordances.

On a communicative level it also means to find different partners or groups, who are able to pick up and investigate feedback in the outlined way. In effect, this type of communication leads to adaptive processes within given systemic frameworks as well as to distinction and differentiation between varieties of systemic settings. This type of communication additionally unfolds demands on the comparative competences amongst communicative partners. And this demand has to be implemented by parallel investigations into the conceptual basis different systemic settings are based on (Figure 5).

This type of communicative intervention allows to rebind deviations from single affordance settings back into academic lessons and to apply the content and the progress of lessons to different scopes of relevance and function. In effect, the communicative demands on such intervention are more complex. Because given feedback could not only be immediately applied or rejected, but even preserved for later treatment, transferred into other contexts of application

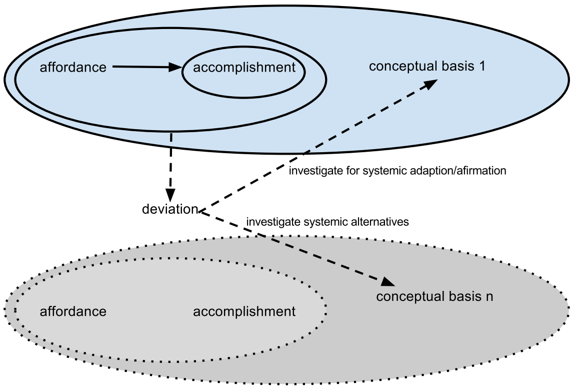

Figure 5: Concept critical intervention into feedback.

and integrated into social discourse about the range of conceptual diversity feedback fits to.

4 SOCIAL CLASSROOM RESPONSE SYSTEMS

Based on the critics and the suggestions for improvement from chapter 3, we will outline a new generation of CRS that is aware of and supports communicative intervention into feedback. The notion of classroom, however, has to be understood in the broader sense of a community of learners; their interaction may occur at the same time and same place (traditional CRS) or at different places (for remote learners) or times (carried over to different cohorts of learners).

This section describes our approach for a social CRS that is aware of social communication. At first we will present the conceptual design for this approach, then we address technical challenges and state feasible implementations for them.

4.1 Conceptual Design

On feedback-events (communicative interventions), when students struggle with an issue, discussions with others can arise. CRS should be aware of these events, because they are a part of students learning process. Similar to bubbles that rise to the surface, discussions can split off the lessons content. Whether or not discussions may not directly related to the lessons content, they are important for their members and can become interesting later on. Moreover, CRS should provide methods to initiate or create such discussion-bubbles. Because students often use their own medium, as social networks or online learning platforms, to discuss an issue, CRS should be able to export discussions. Thereby students are still able to use their known medium for discussion even if they deal with something that has not been created on this medium (enabling concept critical feedback). Figure 6 illustrates this concept.

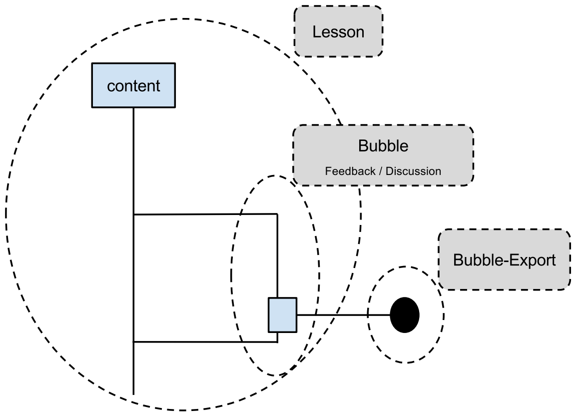

Figure 6: Discussion initiated during a lesson and their possibility for usage in external environments.

In addition to the ability to leave lessons to follow a discussion, CRS have to provide a mechanism to return to a lecture, so students on the one hand can adapt their knowledge generated from the discussion to the current teaching content and teachers on the other hand can react on issues aftereffects. CRS that support to leave to and return from a discussion to a lesson are then able to keep track of learning processes. This enables teachers and students to organize and analyze their own and others learning processes. Furthermore a lecture does now not only consist of teachers knowledge-materials, it also consists of the process how students identify and solve issues on lessons knowledge itself and on teachers learning-materials (adopt systemic affordances and investigate alternatives according to chapter 3.3, Figure 6).

Whereas traditional technical support in a classroom started with a blackboard and evolved via projector to an electronic presentation of learning material. The next logical step is interactive learning material, where the interaction can take place with a preprogrammed digital tutor (systemic intervention), or with a human docent or co-learner (systemic and concept critical intervention). This communication however must not have the usual digital form of interpersonal exchange (such as email, forum etc.) since in this form it is not centered on the topic to be learned or on the learner but rather on the usual human ritual of communication. Rather, new forms of dynamic lecture materials should be developed, where a Q&A session with a docent of a co-learner is directly connected with that place in the lecture material, where the problem arose.

Filtering of content, when a participant is able to select the information he will see, and targeting of content, when a participant is able to designate recipients for his questions, remarks and answers, might be necessary to maintain a reasonable signal-to-noise ratio on a social CRS. This is especially important, when the collection and dissemination of contributions is not restricted to real time classroom activities and may span even courses.

4.2 Technical Design

Regarding the concepts previously described there are many technical challenges for implementations of Social CRS. Because modern CRS clients mostly run on mobile devices we assume that every potential user has a web browser and an internet connection, whether mobile or not. Based on this assumption we identify three main technical challenges. First of all there is the teaching content itself, which is the source of most feedback and the main part of interactive learning materials. Second the discussions, including their participants, references and verbalisations have to be implemented. Third the export of discussions is a functionality that highly depends on other technical frameworks, concepts and standards.

The teaching content mainly covers teachers presentation slides, scripts or any other digital documents. Current web technologies are able to present and distribute all of these documents, so the previous assumptions of an existing web browser enables Social CRS to display nearly every digital content teachers are currently using.

Providing a space for discussion or social communication is mainly covered by feedback type SQ (students questions). Even so discussions can arise from issues on other feedback types, so there has to be an implementation to switch to SQ or at least to initiate a discussion on a different medium. Furthermore discussions can include references to the teaching content, which can be implemented with references to digital objects (pictures, paragraphs, words, videos, etc.) of the digital teaching content. Moreover, social communication needs participants who can be addressable and identifiable. Modern CRS mostly have possibilities for users to use an existing identity, either from their university software system or their social networks. At least all users should be able to address new participants for a discussion and to resign the participation in a discussion. Social CRS can implement this requirement by using the existing identity management.

Exporting discussion or social communication highly depends on targets for an export and needs a specification for addressing. As stated above we recommend a strategy where digital fragments (or digital objects), as paragraphs, slides, pictures, etc, get unique identifiers. Additionally we assign each discussion and each point of discussion an unique id. Over the set of all digital objects and their identifiers Social CRS can span an Application Programming Interface (API), so identifiers are accessible with an unique URL. Thus Social CRS create the ability for an ecosystem around the given feedback. Applications of this ecosystem are able to access all the digital objects even if they were not created on them.

5 CONCLUSION

Our conclusion is that there is a strong need for CRS to allow and support social communication in learning environments. We showed that there are two basic types of communication on providing feedback. On the one hand the systemic intervention into feedback, when students need to deviate their accomplishment due to differences between their understanding and teachers knowledge. On the other hand the concept critical intervention onto feedback, which allows to rebind deviations from an affordance settings and to apply the teaching content and the progress of lessons to different scopes of relevance and function.

Moreover we presented conceptual and technical designs to create a Social CRS that is aware of these types of social communication (of feedback). This includes our approach to handle discussions (communicative interventions), which result from feedback, as important and necessary. CRS should allow to initiate or create discussions as a new part of a lesson that may be progressed in a different medium as well as CRS have to provide a way back to the teaching content. In addition we presented technical solutions for this concept which mainly base on a web application that provides discussion-objects.

In fact of the importance of discussions we are sensible of the distractions Social CRS will create. We see (Social) CRS as a tool for teachers and students that can support the learning process. For this reason one has to be aware that CRS are only able to see a portion of reality. This means that the benefit of feedback and its permanently availability highly depends on students motivation to document their feedback.

Beside this limitation Social CRS and CRS in general are able to become more than just feedback systems. In practice we observed students using CRS to criticize also the system around the lecturer: Some students claimed nuisances on the composition of students with different states of knowledge, which is because the students come from different areas and which is enforced by the university administration. Even if the lecturer recognized this critics as spam at first, he identified it as this critic later on. Keeping this in mind makes it hard to decide if a discussion's level of distraction is worth it or not, even if this discussion might look like spam.

Further research should take up the discussion about social communication with CRS in general. Moreover there are several interesting questions on the discussion export. For example if it is possible to remove an existing export or all related connections. Furthermore it is possible that the ability to document all the social communication can lead to more unrelated information, such as spam, and that such information result in more expense of filtering them. In addition to this question further research can focus on the filtering itself. The filtering itself can be a part of the learning process and may be underestimated.

At least studies on CRS usage are highly important. On the one hand it has to be evaluated how teachers and students use Social CRS and if they get an benefit from them. On the other hand it should be evaluated when students use Social CRS or their documented content respectively. The latter may show that students use their documented social communication mostly for preparation for their exams. Of course this hypothesis is speculative at this point, but such an offline use, however, could require coining a new term, since it no longer is a Classroom Response System.

ACKNOWLEDGEMENTS

This work was supported in part by the German Federal Ministry of Education and Research (BMBF) and the University of Rostock. We gratefully acknowledge the professional and motivating atmosphere offered by them in supporting our study. We thank M. Garbe for discussions and comments on this topic.

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SHORT PAPERS

The Granularity of Collaborative Work for Creating Adaptive Learning Resources

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Keywords: Collaborative Authoring, Learning Designs, Pedagogical Knowledge, Asynchronous, Authoring Granularity, Notes, History.

Abstract: Recent developments in the field of learning systems have led to adaptive learning which considers learner models when performing pedagogical decisions. Problems emerge in providing knowledge spaces of adaptive learning systems. As a knowledge space consists of pedagogical model, learner model, and adaptation model, teachers need much effort to create it. This paper focuses on the authoring of the knowledge spaces of adaptive learning systems and proposes a collaborative authoring approach for creating pedagogical, learner, and adaptation models. The proposed approach combines asynchronous collaborative work with Notes and History to support implicit coordination and workspace awareness. It applies IMS Learning Design to represent the aforementioned models. To validate it, qualitative and quantitative experiments were conducted. The experiment results indicated the high granularity of authoring, which means that learning designers can efficiently and effectively work in an asynchronous collaborative environment with Notes and History.

1 PROBLEMS IN AUTHORING FOR ADAPTIVE LEARNING

Learning is a process to build knowledge and enhance skills through studies, practices, experiences, social interaction, lectures, or tutorials. With many students registering in a course, teachers are faced with various learners' characteristics differs. To accommodate the diversity, recent developments in the field of learning systems have led to adaptive learning which considers learner models when performing pedagogical-related decisions.

Along with its advantages, adaptive learning system gives teachers or learning designers a consequence to prepare a sheer sized and complex learning space, consisting of domain, pedagogical, learner, and adaptation models. Hence, it is difficult for just one or two teachers to develop such a space. Teachers need to work collaboratively to reduce individual effort. Although teachers can work individually on preparing courses, they should team up with other teachers to check material consistency and reliability, or to maintain learning resources which are not fixed at certain stages, and to be kept continuously updated.

A very common collaboration among teachers or learning designers is on creating and reusing learning content. It rarely happens on creating pedagogical knowledge regarding how learning content is delivered. This is contrary to the premise suggesting that learning must be socially developed (McDaniel and Colarulli, 1997). The collaboration of learning designers involves multiple dimensions (pedagogical, social, disiplinary, competency, cultural, et cetera) which potentially improve learning and benefit learners. Learning designers themselves can get advantages from the collaboration as they can learn new knowledge on respective fields from their colleagues.

The collaboration, however, potentially fails when learning designers can not gain concensuses on various pedagogical preferences (Eisen and Tisdell, 2013). Considering the potential advantages and the possible failure of learning designer collaboration, this paper discusses our study on the collaborative work for authoring adaptive learning resources. The study is motivated by a basic question whether learning designers can or cannot collaboratively work on authoring pedagogical, learner, and adaptation models.

In this paper, we propose a collaborative work model for authoring learning designs. In the rest of this paper, we discuss former studies on computer-supported collaborative work (CSCW) and IMS Learning Design (IMS LD) which is the only learning standard supporting adaptation and personalisation. Afterwards, research questions, experiments, and data analysis results are described. The contribution of this paper is presented in the form of a demonstration showing that learning designers can efficiently and effectively work in an asynchronous collaborative environment with Notes and History for creating adaptive learning resouces represented in IMS LD.

2 THEORETICAL BACKGROUND

This paper concerns two issues in authoring learning designers: learning standards to represent adaptive learning resources and computer-supported collaborative work to be applied.

2.1 Computer-Supported Collaborative Work for Learning

CSCW has been successfully applied in various areas for authoring various objects, such as hypermedia documents (Haake, 1993), courseware (Dicheva et al., 2002; Ras et al., 2008), academic writing (Dimitrova et al., 2008), papers (Liccardi et al., 2007), and ontology (Noy and Tudorache, 2008). CSCW in particular enables social collaboration and evolves knowledge on a large scale. It reduces individual efforts, provides different insights, and enhances the quality of output by enabling authors from different expertise to work together (Noël and Robert, 2004). Multiple persons who collectively contribute their thoughts could surpass the achievements of someone who works individually (Dicheva et al., 2002; Posner and Baecker, 1992). However, collaborative work may potentially generate less positive output than individual work. This would be more likely to be the case when inappropriate communication and coordination mechanisms are applied or workspace awareness is limitedly supported (Gutwin and Greenberg, 2002; Kittur et al., 2009; Lowry et al., 2005).

Communication and coordination methods applied in online authoring are different from those applied in traditional collaboration. In a traditional collaboration, careful planning is important. It is supported by face-to-face meeting, which is beneficial to the authors as it offers interactive and direct communication. In contrast, a careful plan is not considered necessary in an online collaboration where contributors have the freedom to do what they consider important. Until recently, there have been numerous research studies into how communication mechanisms affect the authoring process and output. It was found that the proper use of communication method could improve the quality of artefacts (Kittur and Kraut, 2008).

Workspace awareness is important for managing coupling between working alone and working together, simplifying communication, coordinating actions, anticipating other authors' actions, and assisting authors (Gutwin and Greenberg, 2002). Workspace awareness must be maintained, not only in synchronous collaborative work, but also in asynchronous collaborative work. Research on workspace awareness in asynchronous collaborative authoring was carried out with the same motivation as in synchronous collaborative authoring (Dourish, 1997). Workspace awareness in asynchronous collaborative work is related to the history of occurrences, including actions, artefacts, events, and authors' presence and locations (Gutwin and Greenberg, 2002).

2.2 IMS LD Supports for Adaptive Learning

Learning design is motivated by a pedagogic consideration that learning is not merely about a set of learning objects, or simply content to be presented to learners, but learning is also more about how the materials are delivered to learners and how learners can gain knowledge. People learn better if they are actively involved in learning processes (Bonwell and Eison, 1991). Hence, learning is carried out according to a flow of learning activities, called learning design, which consists of a structured set of learning activities to be done by learners and support activities to be carried out by teachers.

The need for learning design standards emerges along with requirements to keep learning designs consistent for all students. In addition, the use of technologies for learning has raised the need for reusable and interoperable digital learning designs. Learning design standards, such as IMS SS and IMS LD (Grocott et al., 2012), present some advantages as they have well structures and abilities to include learning objects as materials in order to support lessons or learning activities.

In term of adaptive learning, IMS LD offers wider adaptation and personalisation than IMS SS. It supports flow-based adaptation, content-based adaptation, and interactive problem solving-based adaptation (Kravcik et al., 2008). 'Hide' and 'Show' are applied to lessons and activities for flow-based adaptation and to resources for content-based adaptation. Furthermore, they are applied for adaptive problem solving assistance which is an extension of flow-based adaptation. It provides incremental-adaptive assistances, for example, by applying time and/or the number of remediation. The structure of IMS LD is presented in Figure 1.

```
title
learning-objectives
pre-requisites
components
  roles
  activities
    learning-activity*
    support-activity*
    activity-structures*
  environments
method
  play*
    act*
      role-parts*
     metadata
```

Figure 1: The structure of IMS LD (Grocott et al., 2012).

There has been an authoring tool of IMS LD. It is called ReCourse (http:// tencompetence-project.bolton.ac.uk/ldauthor/), that provides functionalities for authoring and visualizing IMS LD. In addition, there is CopperCore for validating and delivering IMS LD.

3 RESEARCH QUESTIONS

Regarding the organisation of IMS LD which is hierarchically structured, asynchronous collaborative authoring with implicit coordination was considered suitable. Former research has proved that implicit coordination is more suitable for hierarchical tasks or documents rather than explicit coordination (Lowry, 2002; Lowry et al., 2005). Hence, we hypothesise that learning designers do not need intensive communication for coordination. The hierarchical structure of IMS LD will make authoring task division and assignment not too complicated. In addition, standard meanings and formats for all types of adaptive learning artefacts in IMS LD will prevent a learning designer from missunderstanding other authors' work.

To test the suitability of the proposed method, two experiments were conducted. They addressed two research questions.

Question 1. *With IMS LD that is hierarchically structured, in which level of granularity is the collaborative authoring carried out?*
The proposed collaborative method is suitable for authoring IMS LD if learning designers can collaboratively work on the high and low levels of learning designs, and also on adapting materials. Accordingly, the observation identified the contribution of authors in authoring three kinds of pedagogical elements:

1. *Plays* and *acts*. Plays and acts are IMS LD elements for pedagogical knowledge. Learning designers' contribution in authoring these elements indicates that they can work collaboratively on the high level of pedagogical knowledge, which means that the granularity of authoring is low.
2. *Activities* and *Role-parts*. In designing role-parts, learning designers have to assign learning roles to activities. Updates on learning activities, support activities, activity groups, and role-parts indicate that learning designers can work collaboratively on the low level of pedagogical knowledge. It means that the granularity of authoring is high.
3. *Properties* and *conditions*. Participants' contribution in authoring properties and conditions indicates that they can work collaboratively on adapting materials. An example of conditions is presented in Figure 2.

```
<imsld:conditions>
  <imsld:if>
    <imsld:not> <imsld:or>
        <imsld:no-value>
          <imsld:property-ref ref="P-completion-test-
           advising"/>
        </imsld:no-value>
        <imsld:no-value>
          <imsld:property-ref ref="P-completion-test-
           anticipating"/>
        </imsld:no-value>
    </imsld:or> </imsld:not>
  </imsld:if>
  <imsld:then>  <imsld:show>
        <imsld:learning-activity-ref ref="LA-request-
        grade"/>
        <imsld:environment-ref ref="E-background"/>
  </imsld:show> </imsld:then>
</imsld:conditions>
```

Figure 2: An example of adaptation rule in IMS LD.

Question 2. *Are Notes suitable for implicit coordination and, with History, suitable for workspace awareness in collaborative authoring of IMS LD?*
Experiments to answer this question would refer to former studies on CSCW which have confirmed that coordination mechanisms are group sized-specific.

They have examined the influence of the number of contributors and the independency of collaboration tasks (Kittur et al., 2009). Kittur and Kraut (Kittur and Kraut, 2008) highlighted the correlations between implicit coordination, early stages of authoring, and the quality of articles. The advantages of implicit coordination are greater during the early phases of authoring, when the article is in its earliest versions. During these phases, outlining the article structure by a subset of authors will lead to greater increases in quality. When the authoring work is carried out by the small subset of authors, the quality of articles will increase and is better than articles produced by group where the work is evenly divided amongst all authors.

4 THE EXPERIMENTS

Two experiments were conducted to answer the research questions: a qualitative inquiry with observation and interview and a between-group quantitative inquiry with questionnaires. The proposed collaborative authoring model was implemented by extending ReCourse, a stand-alone open sourced tool, The main functionalities of ReCourse can be classified into five groups:

1. Manage domain model implemented in resources.
2. Manage goal model implemented in learning objectives, pre-requisites, course overview, role, plays and acts, learning and support activities, activity groups, role-parts, conditions, and environments.
3. Manage learner model implemented in global-personal properties for learners' profiles and local-personal properties for learners' progress.
4. Manage adaptation model implemented in pre-defined and user-defined conditional rules.
5. Validate learning designs.

For the experiments, ReCourse was extended with supporting functions for collaboration. The new functionalities in Collaborative ReCourse consist of (Nurjanah, 2013):

1. User group management. The first author is assigned as the coordinator who has an authority to add new members into the group; the others are called members. These are the only role assignments in the proposed authoring method.
2. Notes. Notes were provided in three types based on the types of comments possibly posted by learning designers. First, Note is attached to the whole learning design. It is provided for learning designers to share comments about the learning design itself, learning objectives, pre-requisite courses, completing rules, or other general comments. Second, Note is attached to History, called History's Note, which is aimed to maintain learning designers' comments regarding updates they made. Third, Notes are attached to IMS LD elements, called objects' Notes. One object's Note attaches to one play, act, learning or support activity, activity group, property, condition, role, role-part, or resource. Objects' Notes aim to maintain authors' comments regarding particular elements. The Observation investigated which type(s) of Notes participants prefer.

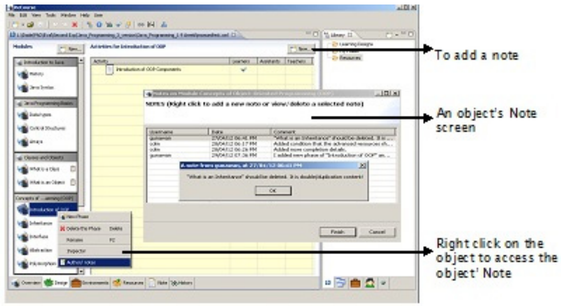

Figure 3: A screenshot of Collaborative ReCourse prototype with objects' Notes.

3. History, a feature to record provenance information about changes, the types of changes, the affected objects, and the learning designers who made the changes.
4. Existing learning content gallery. This is an additional feature in which authors can select, add, or tag learning materials. This feature aims to decrease authors' effort when creating learning content and to enhance authors' awareness of the availability of learning materials to be reused.

The architecture of Collaborative ReCourse prototype can be found in Figure 4.

4.1 Qualitative Inquiry: Observation and Structured Interview

This experiment aimed to observe the granularity of collaborative authoring of learning designs. It investigated how learning designers did collaborative work and on which elements the collaboration was carried out. It investigated whether they could collaboratively work only on the top level of pedagogical resources (plays and acts) or on the low level (role-parts) as well. Furthermore, it observed authors' contribution in authoring adapting materials (conditions and properties). At

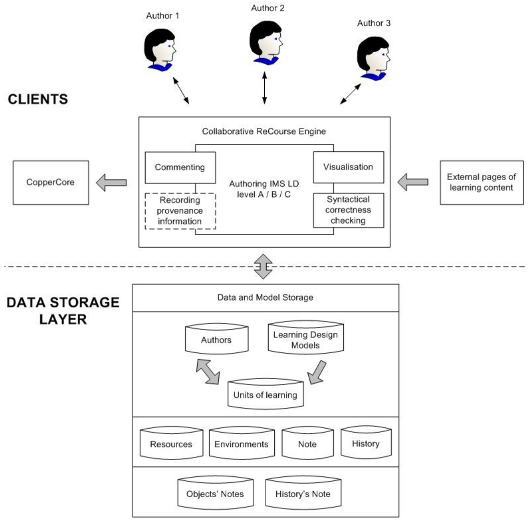

Figure 4: The architecture of Collaborative ReCourse.

the end, a structured interview was conducted after the observation to gather participants' opinion about the authoring process and the collaboration features: Notes and History.

As this is a qualitative experiment, a limited number of participants were required; too many participants will lead to divergent results (Marshall and Rossman, 2006). There were 12 people participating in the experiment. They were recruited by personal email invitation. To select participants, purposeful sampling as opposed to random sampling was used. Participants were selected by considering:

- Gender. Since collaborative authoring of learning designs is not gender specific, male and female participants in a balanced composition were involved in this experiment.
- Teaching experience. Participants were those who had teaching experience in classrooms or laboratories.
- Java knowledge. It was needed because participants were required to develop a learning design of Java programming.

Observation. All participants were assigned to work in asynchronous collaborative authoring environments. They were divided evenly into four groups. In the observation, participants 1 to 3 worked as group A, participants 4 to 6 worked as group B, participants 7 to 9 worked as group C, and participants 10 to 12 worked as group D. Each group was required to create a learning design of Java programming in nine sessions of 60 minutes. Each participant was required to work in three non-consecutive sessions. There was no authoring scenario to be followed by participants; they were free to make any update.

All participants worked in the similar environment: asynchronous collaboration. The only difference is that group C and D were supported by workspace awareness features in the forms of Notes. They could communicate through Notes and access provenance information (History), such as what recent updates that have been made, by whom and when. Such features were disabled for group A and B. Although participants worked collaboratively, the focus of the observation is individual actions in the collaborative work.

Results. The results obtained from the observation were presented in the following graphs. First, the contribution of authors in authoring the aforementioned three kinds of pedagogical elements is presented in Figure 5. As shown in the graph, all participants contributed in the authoring. However, there were two participants in group A and B, participants 2 and 4, dominant over the others in their own groups.

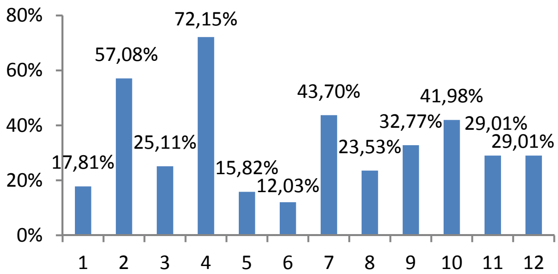

Figure 5: Participants' contribution in authoring all pedagogical resources.

Second, we broke down the data to see the granularity level of authoring which is indicated by the contribution of authors in authoring learning activities and role-parts. As we have discussed, the contribution of authors in authoring learning activities and role-parts indicates the high granularity level of authoring. As shown in Figure 6, all participants participated in authoring learning activities and role-parts in various contribution. Like in the previous finding, there were participants who contributed more than fifty percents in group A and B.

The last focus of the observation is authoring learner model in the form of properties and adapting elements which consist of predefined- and user-defined conditions. As shown in Table 1, all participants contributed in the authoring. However, participants 7 to 12 supported with Notes and History presented better contribution as there were not properties and neither rules which were individually authored by sole participants.

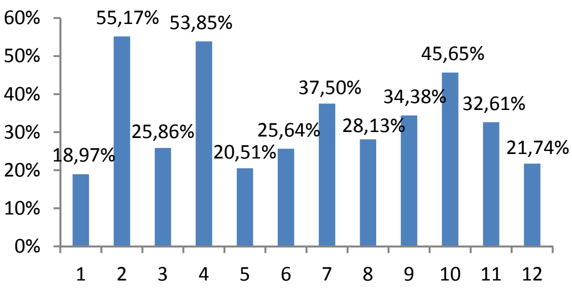

Figure 6: Participants' contribution in authoring activities and role-parts, the lowest level pedagogical resources.

Table 1: Participants' contribution in authoring learner model and adaptation rules.

Participants	Learner model and adapting materials		
	Properties	Predefined Rules	User-defined Rules
1	25.0%		100.0%
2		60.0%	
3	75.0%	40.0%	
4	81.0%		100.0%
5		100.0%	
6	19.0%		
7	16.7%	50.0%	14.3%
8	50.0%	50.0%	57.2%
9	33.3%		28.5%
10	33.3%	50.0%	18.0%
11		40.0%	64.0%
12	66.7%	10.0%	18.0%

Discussion. The observation has investigated how learning designers work in asynchronous collaborative enviroments with features for limited communication (Notes) and awareness supports (Notes and History). It revealed a fact that learning designers can work collaboratively in authoring all IMS LD elements. The granularity of authoring is high as they can work collaboratively from plays to role-parts and from non-adapting to adapting materials. In term of the usability of Notes, the observation shows that among the aforementioned three kinds of Notes, History's Note is the least accessed one. Participants prefer to use Note and objects' Notes as they thought that the function of History's Note has been covered in Note.

4.2 Quantitative Inquiry: Between-Group Questionnaires

IMS LD offers advantages for adaptation and interoperability. IMS LD, however, does not provide an element or any space for learning designers to put notes or comments, such as to explain what the objectives of learning activities, why a particular topic is important, et cetera. We proposed Notes to enable learning designers to put comments regarding the authoring process or the authored artefacts and History that, with Notes, describes how the authoring process is going on. The second experiment aimed to investigate whether Notes and History give positive impacts in authoring IMS LD.

Method. Adaptation model is one component of adaptive learning resources that is considered to be more difficult to understand than other resources. In this study, a comparison between Group 1 and Group 2 was drawn to see if implicit coordination and workspace awareness features is suitable for authoring adaptive learning resources. Both groups are assigned to work in asynchronous collaborative environments, but Group 2 was supported with features for communication and workspace awareness, while Group 1 was not. It could be concluded that Notes and History give positive impacts to authoring, if Group 2 presented better workspace awareness than Group 1.

There were 44 participants who participated in the experiment. The number of participants was estimated by G*Power software (Hendrix et al., 2008). They had teaching experience and Java knowledge. Like in the first experiment, they were required to involve in collaborative authoring of learning designs in asynchronous-collaborative environments.

Participants were divided into two groups. One group was supported with Notes and History, while the other group was not. To guarantee that participants have the same profiles regarding their teaching experience, IMS LD authoring experience, and Java knowledge, we conducted a MANOVA test to see if there is a significant difference between the groups. The test comprising Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root confirmed that there is no significant difference between the profiles of Group 1 and Group 2.

Table 2. The MANOVA results for participants' profiles.

Effect	Value	F	df	Error df	Sig.
Pillai's Trace	.244	2.449[a]	5.000	38.000	.051
Wilks' Lambda	.756	2.449[a]	5.000	38.000	.051
Hotelling's Trace	.322	2.449[a]	5.000	38.000	.051
Roy's Largest Root	.322	2.449[a]	5.000	38.000	.051

Contrary to the first experiment, this experiment required participants to follow artificial authoring scenarios. To give participants knowledge about IMS LD and ReCourse, we arranged a 45-minute introduction session that all participants had to attend. In this session, participants were free to explore the tool and examples of IMS LD.

The questionnaires were reviewed by two senior experts and one junior expert from related fields. The aim of this review was to ensure that targeted information could be gained through all the questions, and to avoid ambiguity of words in the questionnaires that possibly cause misunderstanding. All reviewers had similarity profiles with participants that they have teaching experience as well as educational backgrounds in engineering. As this experiment was carried out not only in the UK, but also in Indonesia, it was essential that at least one reviewer was fluent in both Indonesian language and English.

Results. All participants were required to find information in a predefined unit of learning of Java Programming. They were free to explore the UoL. There was no guidance given to Group 2 participants as to where to find notes written by previous learning designers. Afterwards, all participants were asked a number of questions related to adapting materials. The questions covered five cases; each case employed simple rules and logic that learning designers could easily follow. Participants were required to observe the case and answer questions related to the case. One example of the questions is presented below:

Please find rules. You will find one rule: "Rule 1". What is the objective of the rule?

Participants' answers indicated their workspace awareness. The questions used three nominal values to classify users' answers: wrong answers, no answers, and correct answers. A comparison between the number of correct answers given by Group 1 and Group 2 is described in Figure 7 (Nurjanah and Davis, 2012). In each case, Group 2, which supported with Notes and provenance information, gave a higher percentage of correct answers than Group 1.

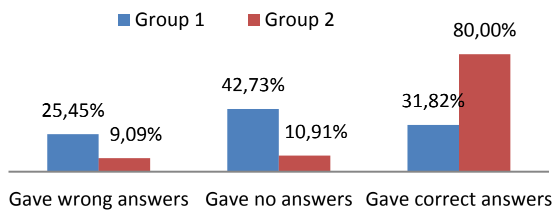

Figure 7: A comparison of users' understanding between Group 1 and Group 2.

Further study was carried out to Group 2. The same approach was conducted to Group 2 in authoring two other courses: Introduction to Biology and Web Programming. A classification of authoring processes were applied to find out whether the proposed authoring approach is suitable only for a particular stage or for all stages. Authoring Biology and Web Programming were in early stages of authoring, while authoring Java Programming was in an advance stage. The experiment result shows that the proposed authoring approach is suitable for both early and further stages of authoring.

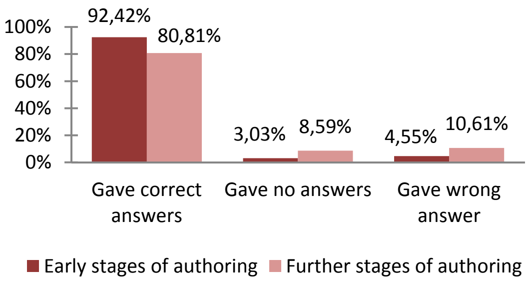

Figure 8: Participants' awareness.

Discussion. In the second experiment, learning designers were required to make some updates in ongoing collaborative authoring. They were required to understand how the authoring was going on. Group 1 could gain awareness only from the curremt states of the authored learning designs, while Group 2 could also learn from the provided Notes and History. The experiment result presents an evidence that Notes and History give positive implication to learning designers' awareness in early and further stages of authoring.

5 CONCLUSIONS

The granularity of authoring indicates that implicit coordination is appropriate for collaborative authoring of IMS LD. The data analysis results showed that participants worked collaboratively in authoring pedagogical knowledge, including adapting materials. The granularity of authoring is high since they did collaboration in authoring all IMS LD elements, including plays and the underlying elements (acts and role-parts), learning/support activities and activity groups, properties, and conditions. As former studies on adaptive learning have proved that people can work collaboratively in authoring learning content, this experiment confirms that they also can collaboratively work in creating pedagogical knowledge (**Conclusion 1**).

Second, the usability of Notes and History was tested through a between-group quantitative study. The study compared the workspace awareness and the contribution of two groups of learning designers; one group was supported with Notes and History, while the other was not. Learning designers supported with Notes and History presented better contribution and higher workspace awareness than the others. They understood what updates had been made, what other authors had done, what the reasons of updates, and who made update. To conclude, the experiment results present evidence that Notes and History give positive impacts in authoring IMS LD (**Conclusion 2**). Another finding was about the importance of Notes. Learning designers considers that Notes and objects' Notes are more necessary than History's Note (**Conclusion 3**).

Finally, although the experiments have confirmed that asynchronous collaborative authoring method with features for limited communication (Notes) and workspace awareness (Notes and History) is suitable for authoring learning designs, further studies to compare this approach with other approaches are required to find the best approach for collaborative authoring of IMS LD.

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An Interactive Textbook for Introductory Engineering Design

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Keywords: Interactive Textbook, iPad, Touchscreen Computer, iBooks, Science Education, Engineering Education.

Abstract: Touchscreen computers hold great promise as educational tools. Many universities, high schools and elementary schools are working to create curricula that exploit these devices. An important part of this work is the development of textbooks that move away from the static display of words and figures to include interactive components such as videos and interactive simulations. We present such an interactive textbook, developed for an undergraduate course in mechanical engineering. We describe the course for which it was developed and the interactive components of the book. Student evaluations of the textbook are presented and discussed. Finally, we offer suggestions for additional steps that can improve interactive textbooks for use on tablet computers.

1 INTRODUCTION

Instructors in science and engineering courses rely on textbooks. Textbooks aid instructors in organizing material, they provide students with information that cannot be covered in lectures, and they provide examples that should assist students in solving homework problems. However, science and engineering students frequently express dissatisfaction with their textbooks and commonly ignore them. Numerous studies of introductory physics courses show that undergraduate students complain about the cost of their assigned textbooks, and that they seldom read these textbooks, leaving them poorly prepared to understand their technical lectures (Stelzer et al., 2009), (Podolefsky and Finkelstein, 2006), (Chen et al., 2010). Much recent innovation in classroom methods and technology addresses this problem of student motivation and preparation in the sciences.

This issue of student preparation is commonly treated as a problem of engagement with the textbooks and the material. Many instructors have approached this problem by adjusting the way they manage their classrooms (Brewe, 2008), (Laws et al., 1999), while others have explored technology to promote active learning and engagement. Zacharia and Anderson (Zacharia and Anderson, 2003) developed computer simulations to address specific student misperceptions. These simulations were integrated with laboratory exercises and produced a positive impact on student learning. Bonham et al. (Bonham et al., 2003) introduced computer grading for physics homework problems and obtained positive results in student satisfaction, as well as student performance. Although the grading system did not provide problem-solving guidance, the system responded quickly enough to enable students to identify and correct their own errors.

Textbook publishers have approached the engagement problem by adding electronic supplements to their textbooks. Cengage Learning (www.cengage.com), for example, provides web supplements for some of its print textbooks, and at least some of the electronic textbooks produced by Pearson Publishing (www.pearson.com) are integrated with websites. However, our experiences with commercial e-textbook web supplements have been disappointing, as supplementary resources appear still to be in early stages of development.

To address the problem of student engagement with textbooks, we have chosen to move away from the resources provided by traditional publishers and towards mobile touchscreen devices such as iPads. These devices are poised to have a significant impact on the way textbooks are prepared and used in college science and engineering courses. In experiments with notebooks and tablet computers, for example, instructors have found iPads to be very effective classroom tools when projects can be developed and programmed entirely on the devices (Liu et al., 2011). When class-specific resources are not developed on the tablet devices, students have been found to enjoy classes that provide them with, for example, iPads, even though the devices themselves have not had a demonstrable impact on student learning (Perez and Paso, 2012), (Perez et al., 2011), (Sloan, 2012), (Van Oostveen et al., 2011), (Weisberg, 2011).

Student engagement may be a function of how richly a tablet device addresses the students' activities in a class. As yet, few textbooks have been developed that exploit computers" ability to provide interactive demonstrations and exercises for the students. It has been argued that publishers have been reluctant to reconceive and redevelop their textbooks to provide such interactivity; Chesser suggests that publishers prefer to port existing books to the tablet devices simply as page images or pdfs (Chesser, 2011). This under-utilizes the computer's ability to provide compelling educational resources to the student. To take advantage of the iPad's potential to engage students, we think that it is important to provide interactive supplements, including simulations, video clips, and homework tools. To directly engage students, these interactive supplements should be tailored for the subject matter of the class, and the book into which they are integrated should speak to student concerns about expense, convenience, and pertinence (Acker, 2011), (Hellman, 2011).

In this paper, we present an electronic textbook that takes steps towards that goal. Our textbook provides simulations that respond to student input, it provides video demonstrations, drawings that the students can manipulate, and design planning tools that students can modify. We have developed this book in an effort to stimulate student engagement while keeping costs low. We will describe the course in which our interactive textbook is used, the particular interactive features that we consider to be novel for textbook authors and compelling for students. We will present student evaluations of this interactive textbook, and we will comment on the future path of development for interactive textbooks.

2 AN UNDERGRADUATE ENGINEERING CLASS

Our interactive textbook was developed for the course Creative Decisions and Design, a sophomore-level engineering design course at Georgia Tech. Enrollment is commonly over 200 students per term, but the students are grouped into studio sections that typically have 20 students per section. The course introduces engineering students to a set of simple tools that address engineering design, teamwork and technical communication. These tools include charts that students fill out in order to better understand the design problem, to partition the problem and to develop conceptual solutions. The tools also include evaluation matrices that support orderly comparison of design concepts. We present these tools in lectures, then students use them to address design projects of increasing complexity. The student project work culminates in the design and fabrication of a mechatronic device using electronic components that we supply. Students demonstrate their devices in an end-of-term design contest. The course has a technical communication component, such that student designs are evaluated according to their presentation in written reports. While student tournament scores are factored into their grades, their grades depend heavily on the written and oral presentation of their work.

Before tablet devices became widespread, the authors developed a print textbook, which was used in this class for several years. As iPads became widespread, we chose to redevelop the print textbook for display on iPads, with the goal of developing supplementary interactive elements to augment the presentation the course material.

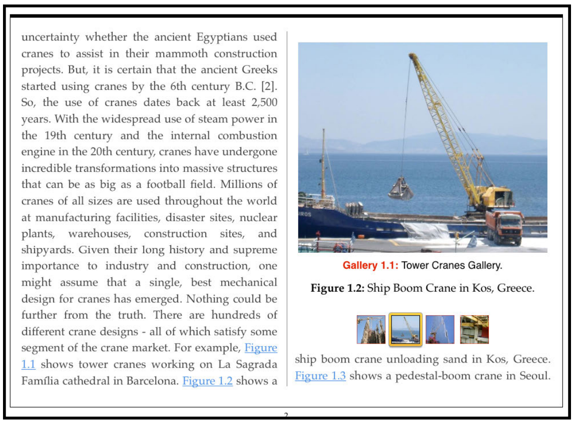
3 DEVELOPMENT OF AN INTERACTIVE TEXTBOOK

To convert our print textbook to an electronic book, we chose to use the editor iBooks Author, as it accommodates a large variety of display types and it is relatively easy to use. This program enables authors to insert the usual array of static displays, such as, photo galleries, presentation slides, and photos with interactive labels. It also allows authors to insert more visually compelling displays, such as videos and 3-Dimensional interactive images that readers can manipulate. Most importantly, it also allows authors to develop and deploy interactive components of their own design. In the following, we present and briefly discuss the interactive elements that we have added to this textbook.

3.1 Photo Galleries

Engineering students and professionals rely on photographs to document designs and to explain events. Engineering textbooks naturally rely on photographs, and instructors often wish to use their own photographs in the classrooms. In our textbook, we chose to use our own photographs because they illustrate our particular approach to the classroom topics and because they illustrate acceptable technical photography. The iBooks Author editor makes it very easy for instructors to add and rearrange photographs in the textbook.

The simplest interactive display provided in iBooks Author is a photo gallery, an example of which is shown in Figure 1. A selected figure is shown in the large, upper frame on the right side. Below it is a gallery of thumbnail images, showing other figures that are available for the reader to select. Galleries such as this save space, as they allow authors to assemble numerous photographs (or other images) in a single spot. This is good for readers, as it assures that photographs will always be displayed on the pages where they are cited. This is useful in engineering and science textbooks, where students are often asked to view groups or sequences of displays in order to identify trends or to understand complex concepts.


uncertainty whether the ancient Egyptians used cranes to assist in their mammoth construction projects. But, it is certain that the ancient Greeks started using cranes by the 6th century B.C. [2]. So, the use of cranes dates back at least 2,500 years. With the widespread use of steam power in the 19th century and the internal combustion engine in the 20th century, cranes have undergone incredible transformations into massive structures that can be as big as a football field. Millions of cranes of all sizes are used throughout the world at manufacturing facilities, disaster sites, nuclear plants, warehouses, construction sites, and shipyards. Given their long history and supreme importance to industry and construction, one might assume that a single, best mechanical design for cranes has emerged. Nothing could be further from the truth. There are hundreds of different crane designs - all of which satisfy some segment of the crane market. For example, Figure 1.1 shows tower cranes working on La Sagrada Família cathedral in Barcelona. Figure 1.2 shows a

Gallery 1.1: Tower Cranes Gallery.

Figure 1.2: Ship Boom Crane in Kos, Greece.

ship boom crane unloading sand in Kos, Greece. Figure 1.3 shows a pedestal-boom crane in Seoul.

Figure 1: Photo gallery with four images.

3.2 Three-Dimensional Interactive Displays

Three-dimensional displays are particularly important in engineering classes, where students must visualize complex systems. In our class, students are expected to prepare professional-quality drawings and to learn how to understand drawings prepared by others. Engineering students are trained to prepare and use three-dimensional drawings, so the inability of print textbooks to accommodate 3-D displays has been a significant limitation for students and teachers alike.

Figure 2 shows three views of a 3-Dimensional drawing of a Segway personal transporter. As presented in our interactive book, this 3-Dimensional drawing can be rotated. View (a) is the appearance of the drawing upon activation by the user. In views (b) and (c), the user has rotated the drawing with a finger swipe. Using this interactive capability, users can examine objects from any angle, a capability that could never be achieved with a print textbook.

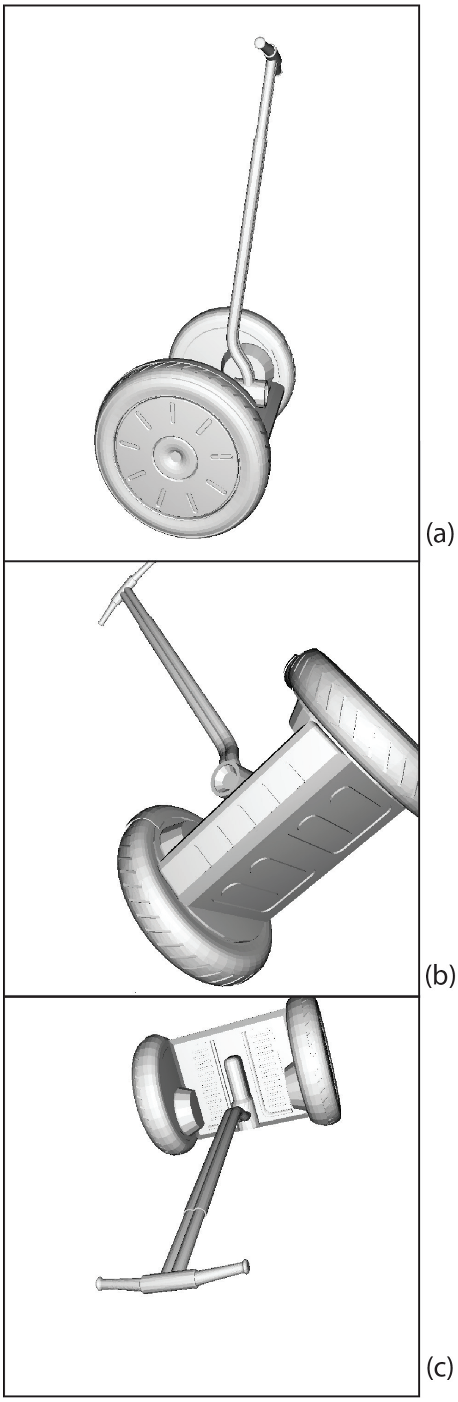


Figure 2: Various stages of an interactive 3-D drawing.

3.3 Embedded Video

Video is a powerful classroom resource because it can provide demonstrations that are more vivid than an instructor's descriptive words. Instructors in science and engineering courses now commonly post video demonstrations on websites. iBook tools allow instructors to embed such videos in the students' textbooks and to upgrade these easily as topics change each term. Figure 3 shows three frames from one of the many videos that we have inserted in our iBook. It shows one of our studio instructors falling from a Segway Personal Transporter, and it is used as part of an introductory project to help students develop customer requirements for the design of a personal transporter of their own.

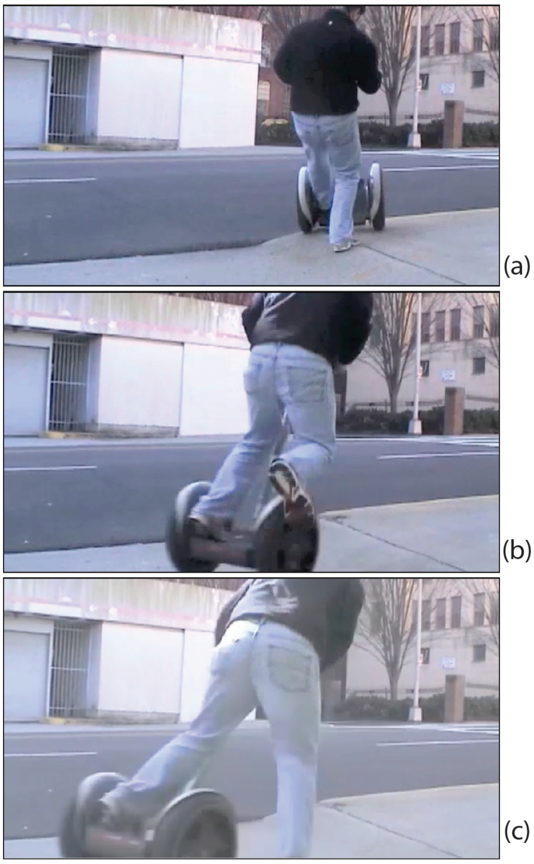


Figure 3: Frames from an embedded video.

3.4 Real-time Interactive Simulations

Real-time simulations can be as powerful as video demonstrations in improving student engagement with scientific subjects. The primary limitation of any print textbook is that the student must imagine how things move and change while looking at single images, diagrams or plots. iBooks Author enables users to code working interactive simulations that students can operate from the pages of their textbooks. In this section, we present two such simulations that we developed at Georgia Tech. One of these represents a bridge crane with a swinging payload, and the other represents an inverted pendulum. In each simulation, the user is asked to move the payload to a target area.

Figure 4 is a screen shot of the textbook showing a 3-D interactive drawing of a crane on the right side. On the left side is an interactive, real-time simulation of a bridge crane. In Figure 5, three screenshots show this simulation in use. It demonstrates the operator's challenge in controlling a swinging payload. At the top of the screen is a box-like representation of a crane trolley to which a square payload is attached via a cable. At the bottom of the screen are orange input buttons that allow the user to raise and lower the payload. Green input buttons move the crane left and right. When users press these control buttons, the crane moves, and the payload swings.

In this simulation, the payload movements are physically correct; the swing frequency changes as the payload is raised or lowered and as the crane is moved left and right. A user can reduce or increase the payloads swing by moving the trolley into or against the payload swings and by raising or lowering the payload. To make the exercise interesting and goal oriented, we have provided the users with an objective; they must deliver the payload to a target box marked by red lines at the right of the screen. A timer allows users to score themselves and to compete with friends.

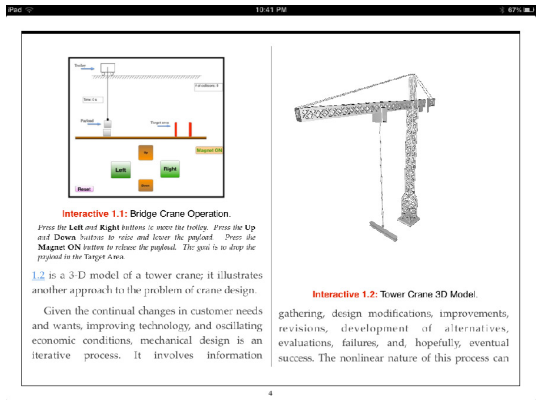


Figure 4: Page with crane simulation and 3-D drawing.

This simulation was developed in the Apple Dashcode environment. The resulting program was then exported as a widget, which is a small HTML snippet that functions like a mini webpage upon integration into an electronic book. This development point is significant; many faculty members have developed simulations as part of their work; our work demonstrates that these can be developed into compelling displays in electronic textbooks.

Figure 6 shows three screen shots of a related real-time simulation that is used in our textbook: an inverted pendulum. This simulation was developed to complement the crane simulation and to illustrate that the problem of controlling an inverted pendulum is

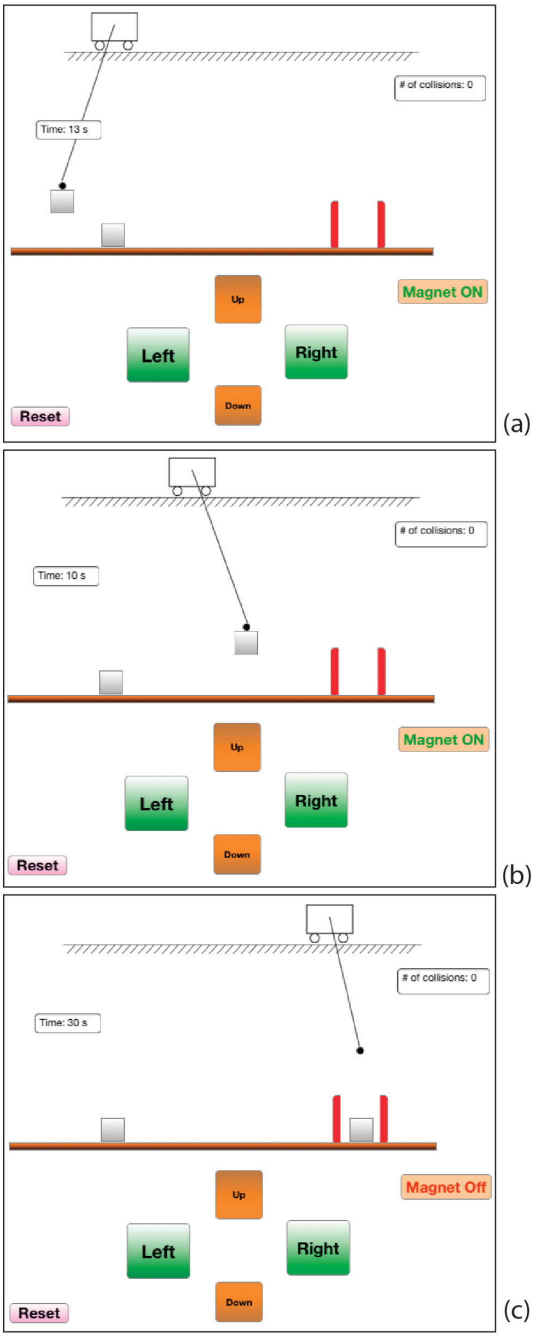


Figure 5: Real-time simulation of crane control.

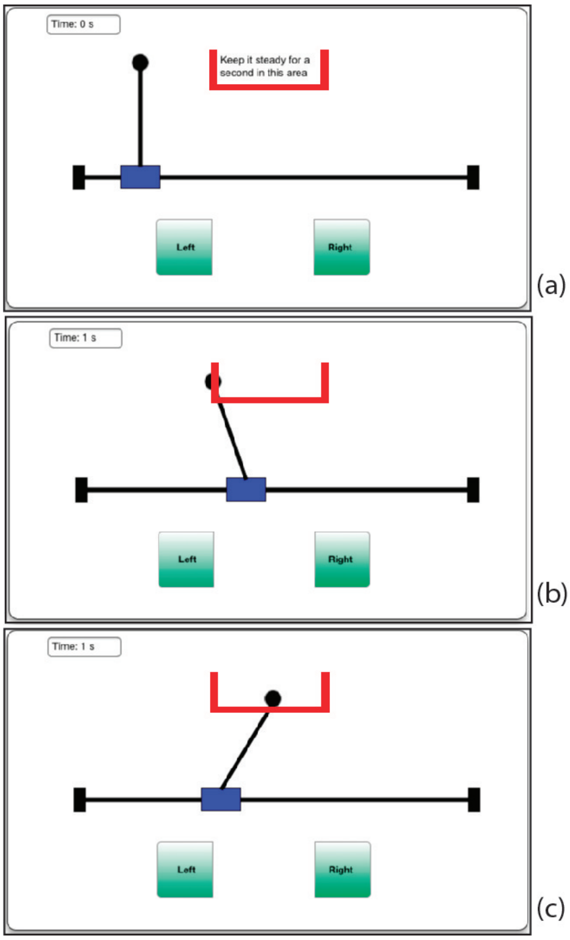


Figure 6: Real-time simulation of segway control.

more difficult than that of controlling the pendulum swing of a crane payload. This simulation is used in a class study of a commercially available inverted pendulum: the Segway Personal Transporter.

In this simulation, the user is challenged to do what a Segway control system is designed to do: maintain the mass stably above the center of gravity and transport it to a target, which is represented as the red area at the center of the screen. To do this, the user must control the blue pivot point below the mass; this is done by using two green input buttons at the bottom of the screen to move the pivot point left and right. As is the case for the crane simulation, the behavior of the system is physically correct; the mass tends to fall when the blue pivot point moves away from the position directly below the mass.

Figure 7(a) shows the starting point for this simulation, with the weight positioned stably above the pivot point. In Figure 7(b), the pivot point has been moved below the red target zone, and the weight, tipped to the left, appears to be falling away from the target zone. In Figure 7(c), the weight is in the target area but falling to the right.

Simulations such as this are crucial for interactive textbooks in the science and engineering domains. They offer realistic representations of complex concepts, and they provide students with a form of hands-on learning. By allowing students to vary the parameters that drive the simulation, tools like this allow students to explore systems in a way that text explanations cannot reproduce. Further, when complementary simulations are paired, as here, students may gain deeper insight into the concepts that are being illustrated. We feel that interactive simulations such as this should be used as often as possible in textbooks for science and engineering students. We believe that authors and publishers should treat this as a priority as they develop textbooks for use on electronic devices.

3.5 Interactive Planning Tools

In addition to designing devices, engineering students learn to use a formal process of defining problems, developing designs, and evaluating design concepts. To guide students through these steps, design courses teach students to prepare a number of planning tools. These tools are specialized flowcharts and tables, with variations in layout that accommodate the designers' needs at different stages of the design process. We ask students to prepare planning tools in order first to insure that design decisions are made in an orderly process, and second in order to create records of their design decisions for later reference. We developed these interactive charts to give the students a simple but fast way to learn how the tools work before they begin work on their own charts.

The first of these interactive planning tools is the Morphological Chart, or "Morph Chart," shown in Figure 7. In a Morphological Chart a designer displays a set of possible design solutions, organized by subfunctions. In this way, the Morph Chart presents all of the possible combinations of ideas for a design project, and designers can develop system design concepts by integrating subsystem components from the Morph Chart.

In the interactive Morph Chart of Figure 8, a simplified list of system subfunctions is shown in the row headings on the left, and diagrams of possible solutions are aligned in the matrix of the chart. In this interactive chart, students can brainstorm possible system designs by directly selecting solutions from the matrix; a possible system configuration is then assembled at the bottom of the display. The concept system display changes each time the user selects or changes a solution; Figures 8(a) through 8(c) show that the display highlights the selections as the user builds a system concept. Using a tool such as this, a user can create a large number of different design concepts.

While interactive simulations are useful for teaching technical concepts, interactive charts are useful for teaching the planning and record-keeping components of engineering projects. Design tools such as the Morphological Chart are fundamental to the mechanical design process as we teach it at Georgia Tech. We believe that they guide students into making

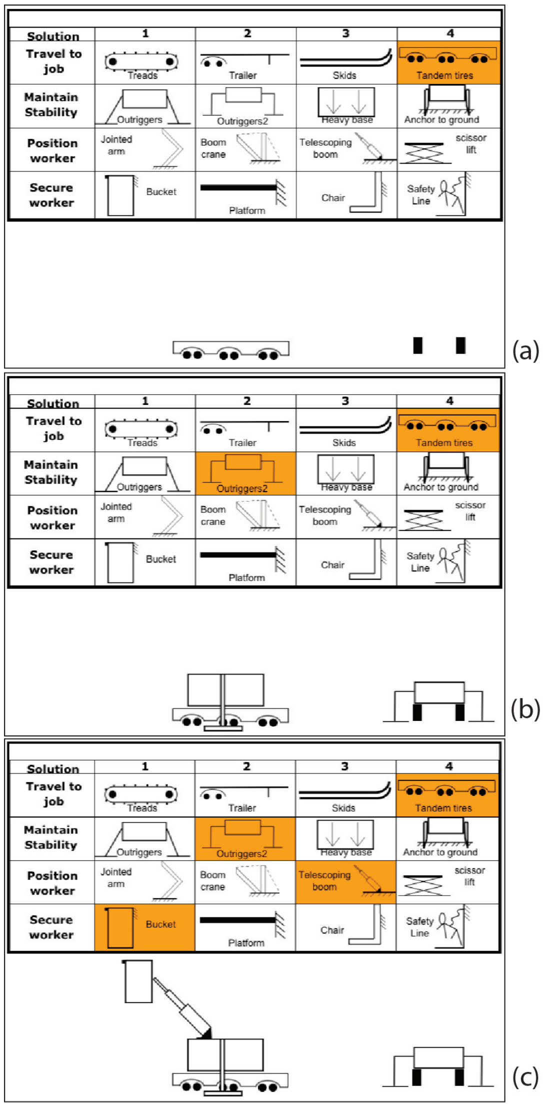


Figure 7: Interactive Morph Chart.

good decisions. By making these tools interactive, we have made them more interesting to learn and more convenient to use.

4 ASSESSMENT

To assess the how well the iBook text engaged the students, we developed a survey to determine whether the students found the book to be useful and to determine which interactive tools, if any, were of greatest interest to them. The survey asked students first to assess, on a scale of 1 to 5, the usefulness of the iBook, and second to assess, on a scale of 1 to 5, the usefulness of the interactive features in general. For both questions, a response of 1 meant "Very Useful," and a response of 5 meant ”Not Useful”; a response of 3 meant ”No Opinion.” In a third question, we asked the students to rank the utility of four of the interactive elements on a scale of 1 to 4, with 1 being the most useful and 4 being the least useful.

Over the course of two terms, we distributed iPads with the iBook textbook, to four studio sections with a total of 80 students enrolled. Of these, 45 students returned completed survey forms to us. Of these, 82%, (37 of 45 students) responded positively, finding the book to be useful or very useful. Three of 45 students (6%) responded negatively, finding the book to be not useful or not very useful. Five of the 45 students, or 11%, gave a neutral response of no opinion.

When asked to evaluate whether the interactive elements were useful, 68% of the respondents (31 of 45 students) rated these to be useful or very useful while 3 students (6%) rated them as not useful or not very useful. Eleven of the 45 students (11%) gave a neutral response of no opinion. These survey results are displayed in Table 1.

Table 1: Evaluation of Textbook and Interactives, Most Useful to Least Useful.

	1	2	3	4	5
Textbook	14	23	5	0	3
Interactives	11	20	11	2	1

To establish the relative utility of the interactive components of the book, we asked students to rank the embedded videos, interactive 3-D drawings, interactive simulations and interactive charts. Here, students ranked the interactive charts as most useful and embedded videos as least useful, with 3-D drawings and interactive simulations tied in the middle. The complete response set is shown in Table 2. The distinctions are small in our survey results, however, and it may be that the different types of displays appeal to different groups of students in a large class.

Table 2: Student Ranking of Interactives Best to Worst.

	1	2	3	4
Videos	9	7	12	13
3-D Drawings	6	13	12	10
Simulations	9	12	12	8
Charts	16	7	5	13

The print version of the textbook, of course, provides no interactive elements to which these results can be compared. The print text offers design tools in static form, and students using the print textbook did find value in these displays; 173 students responded to our survey question regarding the usefulness of the textbook, and 80% of respondents assessed these as “Useful” or “Very Useful,” while no users gave negative responses. These responses are similiar to those obtained for the interactive textbook, and this calls for further investigation into the way that examples are prepared and displayed in print and interactive forms.

5 DISCUSSION AND FUTURE DIRECTIONS

Our survey results demonstrate that students respond positively to electronic textbooks, and we believe that the interactive elements are important to this response. To make our interactive elements compelling, we have made them rich with information related to our class topics. While we have not yet relates textbook use to student learning, our results suggest that this textbook has had an impact on the problem of student engagement.

The current interactive textbook can be viewed as a proof of concept version, and it is reasonable to seek ways to augment it. Generally, we seek new ways for students to interact with our displays. One path of development is to enable students to edit and export the interactive tools for use in other programs. Students might open and modify a 3-D drawing as part of an assignment, for example. Or, our Morphological Chart might be integrated with a drawing tool that would allow students to create, integrate, and evaluate design concepts from within the book’s pages.

In the same fashion, the current tools for editing and organizing reports do not yet provide options for students to test their own ideas for writing and editing. To make such writing and editing tools more richly interactive it will be necessary to integrate them with an Automated Essay Scoring system that provides real time feedback on the students’ written written work.

6 CONCLUSIONS

Our results indicate that students responded positively to this interactive textbook, and to the particular interactive displays that were included in it. These responses are significant because they show that the creating interactive textbooks enables instructors to respond to the problem of student engagement independently and relatively easily. With tools that are easily available, instructors in science and engineering courses can develop textbooks that have a positive impact on their students’ engagement.

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Mastery Profiling Through Entity Linking
To Support Project Team Formation in Higher Education

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Keywords: Collaborative Learning, Computer-Supported Group Formation, Information Extraction, Entity Linking, Mastery Profiling, Graph Exploration, DBpedia Spotlight, Gremlin.

Abstract: Computer-supported group formation enables educators to assign students to project teams. The focus in this paper is placed on gathering data about student attributes that are relevant in the context of specific course projects. We developed a method that automatically produces learner models from existing documents, by linking students to topics and estimating the levels of skill, knowledge, and interest that students have in these topics. The method is evaluated in an experiment with student participants, wherein its performance is measured on two levels. Our results demonstrate that it is possible to link students to topics with high precision, but suggest that estimating mastery levels is a more challenging task.

1 INTRODUCTION

Group-based learning has taken an important role in curricula across the educational spectrum. One aspect of group-based learning that has attracted considerable attention from researchers, is the formation of groups of learners. Group formation influences the interactions that group members have, and thereby affects the results of the learning experience (Kyprianidou et al., 2011). Poorly formed groups may suffer from, for example, an unproductive use of time or incompatible personality types. The way students are partitioned into groups also raises the question if they can be assessed fairly, e.g. due to an unbalanced spread of skills (Livingstone and Lynch 2000).

In higher education, common group forming methods are student self-selection and random assignment. These methods do not necessarily lead to good learning experiences, but are often the only practical alternatives for instructors who teach large numbers of new students each year. Instructors might lack the necessary information about the students to implement a more elaborate group formation process, or face the impracticality of manually solving a large combinatorial problem (Craig et al., 2010). This has motivated research towards the development of tools that can aid instructors in forming groups, which is known as Computer-Supported Group Formation (CSGF) (Ounnas et al. 2009).

Regardless of the algorithms that are used, the criteria that can be used in the group formation process are limited by the data that is used to describe the students. Hence much of the previous work makes use of student attributes for which standardized tests are available, such as team roles, personality types, and learning styles (Magnisalis et al., 2011). Important disadvantages of gathering student data in this way are the dependence on lengthy questionnaires, and the need to ask students new questions when course-specific characteristics are taken into account.

In computer-supported collaborative learning settings where the majority of learning occurs in a virtual environment, there are opportunities to gather relevant data about students continuously. In more traditional settings, it may instead be viable to use data from existing resources that describe students, specifically to model students' mastery of topics. Previous suggestions are to use text mining techniques on curricula vitae (CVs), academic transcripts, and personal websites (Ounnas et al., 2009).

The objective of this study is to develop and evaluate a method which allows existing data sources that describe students' mastery levels (e.g. of knowledge, skills, and interests) to be automatically combined into a learner profile for use in CSGF algorithms. The scope of group formation problems that need to be addressed by this method is restricted to the domain of team project-based higher education. To work towards this objective, the main research question that this paper addresses is formulated as follows:

Can existing data sources that describe students' mastery of topics be fused into a learner profile, to facilitate computer-supported group formation?

The remainder of this paper is structured as follows. In Section 2 we discuss related work. Section 3 serves to briefly describe a further exploration of the problem domain. In Section 4 we discuss gathering existing resources from student participants. Based on these resources we produce learner profiles, using a method that is described in Section 5. In Section 6 we discuss our evaluation approach and results, followed by the conclusion and future work.

2 RELATED WORK

2.1 Computer-supported Group Formation

CSGF is based on the idea that instructors can assign students to groups by making explicit educational criteria according to which groups should be formed (Craig et al., 2010). The essence of CSGF is: the synthesis of groups by applying criteria that optimize aspects of each group, by making use of data about the individual learners (Magnisalis et al., 2011).

A classification, originating from literature on team diversity, divides relevant attributes into *task-related* (e.g. knowledge, skills, experience) and *relations oriented* (e.g. gender, culture, attitude, social ties) (Jackson et al., 1995). Task-related attributes of individual students are relevant because they indicate which cognitive resources will be available in any possible grouping. Relations oriented attributes indicate how group members are expected to interact. A common approach to recording task-related attributes is to ask students for their grades in selected prerequisite courses (Lingard and Berry, 2002). Another approach is to measure skill levels for a few domain-specific skills by questionnaire (Winter, 2004).

Most of the criteria according to which groups should be formed can be classified as *homogeneous*, *heterogeneous*, or *apportioned* (Craig et al., 2010). Both homogeneous and heterogeneous criteria are concerned with the distance between students within a group for a specific attribute, while apportioned criteria serve to distribute a specific attribute as evenly as possible across the groups.

Hoogendoorn (2013) has recently conducted three field experiments which provide evidence for the effect of heterogeneity on the performance of student teams. His results suggest that gender diverse teams perform significantly better than male-dominated teams, and no worse than female-dominated terms. The effect of ethnic diversity on team performance is found to be positive for teams where at least half of the members have different backgrounds. Diversity in cognitive ability of team members only shows a positive effect on performance when the degree of heterogeneity is moderate. Heterogeneity of cognitive resources is suggested as an underlying mechanism for the effect of diversity in ethnicity and cognitive ability.

Other researchers argue for certain criteria without empirical support (e.g. based on expert opinion). Most arguments are made for heterogeneous criteria (i.e. complementary fit) on specific attributes, including skills, knowledge, abilities (Wells, 2002; Werbel and Johnson 2001; Wilkinson and Fung 2002), and learning styles (Magnisalis et al., 2011). Student interests and values should however be grouped homogeneously (Werbel and Johnson, 2001). Grades in prerequisite courses are most often apportioned (Craig et al., 2010; Ounnas, 2010).

2.2 Entity Linking

Entity linking (EL) is the information extraction task of automatically *"matching a textual entity mention [...] to a [knowledge base] entry, such as a Wikipedia page that is a canonical entry for that entity."* (Rao et al., 2013, p. 96). Three key challenges have been identified for EL to deal with: name variation, entity ambiguity, and absence (Dai et al., 2012; Rao et al., 2013). Name variation entails that an entity can be referred to by multiple different terms. Entity ambiguity refers to the issue that a single name string can match with several distinct entities. The issue with absence is that when no knowledge base (KB) entry exists for the entity that is mentioned in the text, no entity should be returned, rather than the highest-ranking KB entry.

There are, however, two relevant limitations present in the existing work on EL. Most research focuses explicitly on linking *named* entities (i.e. entities referred to by proper names), specifically on persons, locations, and organizations (Mendes, Daiber, et al., 2011; Rao et al., 2013). Additionally, many current approaches are evaluated only on English-language texts, with a focus on the news domain

(Mendes et al. 2011; Rao et al., 2013).

DBpedia Spotlight is an open-source system that can annotate any given input text with DBpedia resources (i.e. KB entries), which are based on semantic extraction from Wikipedia articles (Mendes, Jakob, et al., 2011). Several parameters provide the means to filter annotations according to task-specific requirements. By default, DBpedia Spotlight is not specialized towards specific entity types, but it may be configured to annotate only instances of specific types, either by selection of classes, or by arbitrary SPARQL[1] queries (Mendes et al., 2011).

When linking targets are known to have a specific type, e.g. genes (in the biomedical domain), annotating only those entities is quite straightforward (Dai et al., 2012). If a domain-specific vocabulary already contains links to DBpedia or Wikipedia then one can consider all DBpedia Spotlight candidate entities, and then check whether the top-ranked candidate has a corresponding entity in the local vocabulary (Mendes et al., 2011).

Multiple EL researchers have found it helpful to include a measure of *semantic-relatedness* between entities in the disambiguation process (e.g. Han et al., 2011). The intuition behind collective entity disambiguation is that the links between, e.g., Wikipedia articles reflect how closely the corresponding entities are related, and that texts are more likely to mention several related entities than entirely unrelated entities.

Besides using metrics of semantic-relatedness and disambiguation purposes, it might be feasible to use them to find additional topics in which a student has some mastery. For instance, when a student's CV mentions that she is skilled in technical drawing, we can infer that she has some skill in drawing in general.

3 VIEWS ON FORMING TEAMS

In the group formation literature arguments are made for the relevance of skills, knowledge, abilities, interest, and grades. All arguments are, however, made from the educator's perspective, and information about the student's perspective is lacking. We have therefore surveyed a group of university students and asked them about the considerations they have had while forming project teams in the past.

As in other group formation studies, we recruited participants from a subpopulation of students who study the same subject (Lingard and Berry, 2002; Winter, 2004). All participants were enrolled in the MSc program *Design for Interaction* at the Delft University of Technology (DUT), and were recruited through a mailing list. The same sample of students were respondents to the questionnaire as well as participants in the experiment that is described in subsequent sections.

The questionnaire was taken by 11 students. We focused our questions on seven attributes: *competence, education, experience, general ability, interest, knowledge, and skill*.

The results of the questionnaire broadly correspond to what was found in the CSGF literature. On this basis, we decide to include skill and knowledge in our learner profiles. We also include interest in our profiles because it is used in team formation criteria by many instructors (Werbel and Johnson 2001; Kyprianidou et al., 2011). Competence, we argue, is not a suitable choice because it depends on specific skills and knowledge.

4 GATHERING EXISTING RESOURCES

After finishing the initial questionnaire, students were asked to participate in creating a learner profile based on existing documents about them. To participate, they needed to provide access to a project portfolio, an academic transcript, and temporary access to their LinkedIn[2] profile, and/or provide the URL to a personal website. The terms that indicate relevant attributes need to be recognized in these resources, and should be linked to a shared vocabulary in which the learner profiles can be expressed. The quality of the resulting profiles is evaluated by comparing them with a ground truth that is given by the participants.

The decision to gather academic transcripts, CVs, and personal websites was motivated by suggestions found in literature (Ounnas et al., 2009). Although documents in a project portfolio do not describe students in the same sense as the other document types do, they can give a more detailed view of the specific topics a student has engaged with during previous projects (at least for a human reader).

Participants' academic transcripts and LinkedIn profiles were saved by a sign-up application. The course descriptions that correspond to the course identifiers in the academic transcripts were retrieved

[1] SPARQL 1.1 - <http://www.w3.org/TR/sparql11-overview/>

[2] LinkedIn - <http://www.linkedin.com/>

through the DUT API[3]. The project portfolios consist of deliverables, such as reports, presentation slides, and project blogs. The corresponding files were provided by Shareworks Solutions BV. For the two participants who provided a website, we saved the pages manually.

In total, 10 LinkedIn profiles (all English), 190 course descriptions (66 Dutch, 124 English), 54 portfolio documents (2 Dutch, 52 English), and two websites (both English) were gathered. Participants were associated with between 15 and 57 documents; on average with 37 documents. Most course descriptions and some portfolio documents were associated with more than one participant.

5 PRODUCING LEARNER PROFILES

Two existing implementations of DBpedia Spotlight are used to produce *annotations* that we define as "links between a phrase in a document and a topic, which is represented by a DBpedia URI". Subsequently, we estimate skill, knowledge, and interest levels by taking into account surrounding terms of each annotation, document origins, and annotation frequencies. The learner profiles that are produced by this method consist of *statements*, where a statement is "the relation between a student and a single topic, which is quantified by three mastery levels. Finally, the set of statements in each profile is expanded by inference over probabilistic and semantic relations between topics.

5.1 Vocabulary Selection and Modification

CSGF differs from the current applications of entity linking: when links are generated for the readers of an article, it is assumed that the readers are familiar with the majority of abstract concepts that are mentioned. For CSGF, abstract concepts are mostly relevant, and people and places less so. To annotate documents only with topics that are relevant for CSGF, we test the approach taken in Mendes, Daiber, et al. (2011) and in Wetz et al. (2012), for which we require an application-relevant subset of DBpedia entities.

We use the LinkedIn "Skills & Expertise" vocabulary[4] V_{LI} as a basis. Reasons to choose this vocabulary are that it is already partially linked to Wikipedia, and that it is used daily by thousands of people to describe their professional abilities. From V_{LI}, we define our vocabulary $V = V_{\mathrm{LI}} \cap DBpedia$. There are 26 292 topics t in V; nearly 70% of $t \in V_{\mathrm{LI}}$, but only 0.7% of all DBpedia resources. The links between V_{LI} and Wikipedia contain inaccuracies. We have manually corrected 40 of such links, but we estimate that at least 10% of $t \in V_{\mathrm{LI}}$ are needlessly missing a link, or are linked to an incorrect Wikipedia article.

V_{LI} only links topics with English Wikipedia articles, and as such V would only include English identifiers for topics. Since our profiling method also needs to deal with documents in other languages, we incorporate alternative topic identifiers into V by using Wikipedia's *interlanguage links*[5]. For each $t \in V$ the Dutch identifier nl (if available) is retrieved from the nl.dbpedia.org SPARQL endpoint through the query:

```
SELECT ?nl WHERE {?nl owl:sameAs
<http://dbpedia.org/resource/t> .}
```

There are topics that are mentioned frequently in all types of the gathered resources, but that are not relevant for learner profiles. We exclude 56 of such topics in total from V.

5.2 Information Extraction Pipeline

The information extraction process that we employ lends itself to being described as a data transformation pipeline.

For each gathered document $d \in Documents$, a DBpedia Spotlight implementation, given a configuration, annotates the content per section. The resources that are returned are filtered with our vocabulary.

In each section we count *qualifying terms*, which indicate specific types of mastery, and linearly combine the normalized counts with $(Skill, Knowledge, Interest)$ weights that depend on the document origin $o(d)$. The resulting (s, k, i) score is assigned to each annotation within the section, after which the scores are summed per topic for the entire document. The summed scores are stored in the document (d_{OUT}) as indications of mastery, where one $indication = (t, (s, k, i))$.

Hereafter, we select for each profile $p \in Profiles$ the d_{OUT} that are associated with p by a document link $dl = (p, d)$. The indications in the associated documents are summed per (t, o), resulting in $1..|o|$ mastery levels scores, where one

[3] Delft University of Technology API - <http://apidoc.tudelft.nl/>

[4] LinkedIn Skills & Expertise - <http://www.linkedin.com/skills/>

[5] See: <http://en.wikipedia.org/wiki/Help:Interlanguage_links>

$mls = (s, k, i)$, for each unique topic that is associated with p. The indications that originate from course descriptions are, before summation, weighted by the grade that the student received for the corresponding course.

The maximum s, k, and i scores of the summed indications differ significantly between origins. For each origin, the scores are linearly transformed to the range $[0, 100]$, because we wish to compare the accuracy of statements from different origins in our evaluation. The resulting normalized indications represent the relative mastery levels per topic for a single student, i.e., they encode beliefs that the student has more mastery in one topic than in another.

For CSGF the aim is to compare the mastery levels per topic between students. A final data transformation is thus needed. Each normalized $mls_{t,o}$ is transformed to its percentile rank (PR) $mlpr_{t,o}$in the frequency distribution of the mls with the same (t, o) from all profiles. Finally, statements are saved as $statement_{p,o} = (t, mlpr)$.

5.3 Linking Documents to Topics

The first step in our approach to mastery level profiling is to ask for each student: in which topics does this student have any skill, knowledge, and/or interest? We use entity linking to answer this question based on the gathered documents, in lieu of more tailored information extraction techniques. This enables us to test the hypothesis that:

"From all entities that are mentioned in the documents associated with a student, a vocabulary can be used to select the entities that are topics in which this student has some mastery".

5.3.1 Annotation Method

Two DBpedia Spotlight implementations (Mendes, Jakob, et al. 2011; Daiber et al. 2013) are used and configured to produce annotations in our experiment. The original Information Retrieval-based implementation, with the default configuration, spots all phrases in the input text that also occur in a dataset of possible surface forms for all DBpedia. It selects candidate entities for each spotted phrase, and ranks them according to the prior probability that the observed phrase refers to the selected candidate. The candidates are then re-ranked by querying a Vector Space Model (VSM), in which entities are represented by the paragraphs that mention them in Wikipedia, with the context of the observed. Top-ranking candidates are the most likely disambiguations.

The newer statistical model uses a generative probabilistic model for disambiguation. This model is used to calculate a disambiguation score for entity e, given the spotted phrase s and its context c, by combining $P(e)$, $P(s|e)$, and P. The original phrase spotting method is used in parallel with a Natural Language Processing (NLP) method that is not limited to surface forms that occur in DBpedia. Any overlap in spotted phrases is resolved, after which the phrases that fall below a score threshold α are dropped from the annotation process.

In both implementations the *topical pertinence* of a candidate for the observed context is indicated by the disambiguation score. The relative difference in this score between the first and second ranking candidate indicates *contextual ambiguity*, i.e. how uncertain it is that the top-ranked candidate is the entity that is mentioned in this context. The *confidence* parameter, which is provided at runtime, applies a threshold of $(1 - confidence)$ to candidates' contextual ambiguity scores. A second runtime parameter, *support*, specifies the minimum number of Wikipedia inlinks a candidate resource must have to be further considered.

We define a third runtime parameter which chooses between *single* and *multiple candidate filtering*. In single candidate filtering, we take the set of top-ranking entities E_s that Spotlight produces for a section and select as topics the entities that occur in our vocabulary ($T_s = E_s \cap V$). In multiple candidate filtering we instead initialize $T_s = \{\}$, take the set of ranked candidate vectors $R_s = \{\bar{r}_1, \bar{r}_2, \dots, \}$, and from each vector we add the top-ranking topic to T_s (denoted $T_s \cup \{t_1\}$, where $t_1 = e\colon e_{\min(j)} \in \{e_j\colon e_j \text{ in } \bar{r} \text{ and } e \in V\}$).

5.3.2 Exploration of the Parameter Space

To assess the suitability of various configurations for producing learner models (before the ground truth is given by the participants), we have manually annotated a small test collection of documents, and have measured the performance of our annotation method on this collection.

We use the measures *precision*, *recall*, and *F-score (F_β)* to evaluate the performance of the annotation method. The definitions of these measures are adapted from the prevailing definitions in entity linking (Han et al. 2011) to better suit our annotation task. Let $learner$ be the person who is profiled in p, with the set of associated documents $\{d_{\text{OUT}}\colon dl(p, d)\}$. $Generated_p$ is the set of all topics with which $\{d_{\text{OUT}}\colon dl(p, d)\}$ has been annotated. $Truth_l$ is the set of all topics in which $learner$

claims to have some mastery.

$$precision = \frac{|Generated_p \cap Truth_l|}{|Generated_p|} \quad (1)$$

$$recall = \frac{|Generated_p \cap Truth_l|}{|Truth_l|} \quad (2)$$

$$F_\beta = (1+\beta^2) \times \frac{precision \times recall}{(\beta^2 \times precision) + recall} \quad (3)$$

In this work $\beta = 0.5$, which reflects our assumption that recall is only half as important as precision for this annotation task.

For the test documents we have had to use $Generated_d$ and have created $Truth_d$. In $Truth_d$ we have only included the topics for which d implied some mastery on the part of any student associated with d.

To find which configurations perform best for our annotation task, we have performed a parameter sweep on 3 Dutch and 8 English test documents. Because we were not able to assign a value to the threshold α, we have instead manipulated a spot score weight which, when enlarged, increases the probability that spotted terms are annotated.

With both languages, a clear tradeoff between precision and recall can be observed. Multiple candidate filtering, as expected, results in higher recall, but lower precision, than single candidate filtering. Increasing the confidence value causes higher precision, but lower recall. We found the effect of the support parameter to be negligible.

Based on these results, we continue our main experiment with the IR-based implementation and $confidence = 0.3$ for English documents, and the statistical implementation with a spot score weight of 0.4 and $confidence = 0.2$ for Dutch documents. For both languages we use single candidate filtering and $support = 0$.

5.4 Estimating Mastery Levels

To estimate which type(s) of mastery a student has in a topic, we have selected the descriptions of the 25 most attended courses, and recorded all terms that imply skill or knowledge (i.e. qualifying terms).

We represent the qualifying terms as sets, and count for every section that contains annotations how many terms indicate skill and knowledge. Stemming is used to also count lexical variations of the terms. Predefined weights per document origin are linearly combined with the fractions of skill and knowledge term counts, to produce a (s, k, i) score per annotation in a section. In the defined weights, we assume that portfolio documents and websites indicate each type of mastery, but that course descriptions do not indicate any interest.

In our definition of mastery levels we need to take into account that the ground truth that we will use in our evaluation is provided by the participants. The scale and unit in which mastery levels are expressed need to be understood by students to allow them to accurately correct their profiles (Bull and Kay 2007). In our model a mastery level means that a student has more knowledge, skill, or interest in a topic than a percentage of his or her peers. *"Paul (Knowledge, 75) Archery"*, for example, would indicate that Paul has more knowledge about archery than 75% of his peers.

To estimate mastery levels, we use the intuition that a student will have more mastery in topics that are mentioned more often in the associated documents. For the topics that originate from course descriptions we also incorporate the grade that a student received and the extent of the course. Each indication of mastery that originates from a course description is multiplied by a weight $g_{p,d}$, which is calculated as:

$$g_{p,d} = \frac{0.5 \times (2 + ECTS\_credits_d)}{11 - grade_{p,d}}. \quad (4)$$

All indications in the associated documents for a single student are subsequently summed per (t, o). Hereafter, the indications are normalized per origin, but across profiles, to the range $[0, 100]$, so that for each (t, o) there exist maximum s, k, and i scores with the value 100. This enables us to generate indications for a fifth origin ALL, in which we have compensated for differences in annotation frequency and weighting between topics and origins. The indications for *ALL* are generated by summing the existing indications per profile.

Finally, indications are transformed into statements with the desired semantics by using the frequency distributions of s, k, and i scores, again per (t, o), over all profiles. Each score is transformed into a mastery level by calculating its percentile rank in the corresponding frequency distribution. But because mastery levels are defined relative to a student's peers, we would need frequency distributions that include all peers.

To compensate for the limited number of participants, we apply a form of additive smoothing in the calculation of percentile ranks. Into each frequency distribution $m_{t,o}$ we insert the values 0.0, $1.5 \times max(m_{t,o})$, and $(|m_{t,o}| - 1)$ evenly spaced values in between. The percentile ranks of individual indications are computed from these modified frequency distributions.

5.5 Expanding Profiles by Inference

Because our vocabulary is not a KB, in the sense that it contains no information about relationships between topics, we use DBpedia as a source for semantic relations between topics. We aim to predict for each student, on the basis of the topics that are linked from their profile, in which other topics they are likely to have some mastery.

We use Gremlin[6], which implements efficient graph traversal as described in Rodriguez & Neubauer (Rodriguez & Neubauer 2011), to traverse the semantic network of DBpedia. For each topic (node) in a profile, the `dcterms:subject` links are followed to the categories the topic is a member of, from where `skos:broader` and `skos:narrower` are followed to neighboring categories, up to two levels outward. At each category node that is visited during the traversal, the contained topics are also visited, and the frequencies of these visits are counted as a side effect. When the traversal is finished, we take the frequency table, and store it as a measurement of the relatedness between the starting node and the visited topics.

Then, to infer which newly found topics should be included in the profile, we summate the frequency tables of all topics in the profile. From the resulting table, we ignore any topics that are already in the profile, and take the top-10 related topics that are in our vocabulary, and the top-10 topics that are not in our vocabulary.

LinkedIn uses a proprietary algorithm, which likely incorporates aspects of collaborative filtering, to display 20 "related skills" on each of the pages that we used as the basis for our vocabulary. Such lists of related skills are added into a frequency table for each profile, and are further treated identically to the inferences from DBpedia.

6 EVALUATION

The ground truth against which we measure the performance of the method is provided by 8 participants. We have provided them with an interface that allowed them to review and correct their own profile. First they were presented with 184–353 topics that were extracted from all types of documents ($o = ALL$). Participants were asked to remove all topics in which they had no mastery by clicking the corresponding buttons.

The second step for the participants was to correct the estimated mastery levels. Here, statements were presented as boxes (again including the topic name and description) with three sliders for the skill, knowledge, and interest level. Due to the large amount of extracted statements, we randomly omitted 50% of the statements that were based only on extraction from course descriptions or portfolio documents.

The third step was similar to the first, except with 20 inferred topics from DBpedia, and 20 inferred topics from LinkedIn. In the fourth and final step, the participants were asked to add any topics in which they had mastery that were missing from their profile.

It is worth noting that people are prone to over- and underestimating themselves (Dunning et al., 2003). This is, however, not a weakness of our experiment in particular. In CSGF it is still quite common to base a profile of task-related attributes solely on the information that is provided by the learner in question.

The measures *precision*, *recall*, and $F_{0.5}$-*score*, which have been defined in Section 5.3.2, are used to evaluate the performance of our annotation process. We do not average our measures over the profiles, but rather take the counts of $Generated_p$, $Truth_l$, and their intersection per profile, sum the counts, and then compute precision, recall, and $F_{0.5}$ over all profiles. To assess how successful we were at estimating mastery levels, we test for correlation between the estimated and actual levels. We use Pearson's correlation coefficient (r) as a measure, and we report on statistical significance at the levels of 0.10 (˙) and 0.001 (*). Because we included a limited number of inferred topics in the participants' profiles, we cannot use exactly the same measures as with the extracted topic links. Instead, we use *Precision at 10*, which denotes the fraction of inferred topics in which the participants claim to have mastery.

Our results (see Table 1) indicate that the combination of extracted information from all document origins leads to the most accurate profiles. The profiles included a large amount of topics in which the participants actually had some mastery. Course descriptions are the only type of document that could be used to produce profiles of similar quality by itself. Documents from other origins lead to topic links with a comparable precision, but in a quantity that is likely not sufficient for application in CSGF.

[6] Gremlin - < http://gremlin.tinkerpop.com/ >

Table 1: Performance of the Mastery Profiling Method.

Extracted						
Origin	**Topic Links**			**Levels Corr.**		
	Pr.	Re.	$F_{0.5}$	Sk.	Kn.	In.
Coursed.	0.859	0.711	0.825	.210*	.212*	—
LinkedIn	0.935	0.077	0.290	.060	.108	.047
Portfolio	0.811	0.184	0.482	.220*	.058	.073
Website	1.000	0.003	0.013	.853	.696	.700
ALL	0.845	0.860	0.848	.268*	.241*	.299*

Inferred		
In-Vocabulary	**DBpedia Pr. at 10**	**LinkedIn Pr. at 10**
Yes	0.825	0.925
No	0.750	0.875

Inference can be used to expand learner profiles with high precision. The additional topics that are found by taking into account probabilistic relations between topics from LinkedIn are more precise than those that are found from a traversal over the semantic network of DBpedia. It is more accurate, in both cases, to filter the inferred topics with our vocabulary. A large majority of the inferred topics that are not in our vocabulary is, however, also correct.

Our method was not able to estimate mastery levels with the accuracy that is necessary for CSGF. The estimated mastery levels show a weak but significant correlation with the levels that the participants reported. The differences between origins suggest that course grades and qualifying terms are both indicators for mastery levels, but that the number of sections that is annotated with a given topic is a worse indicator than we expected.

7 DISCUSSION

Our annotation process has produced results that are very promising for use in CSGF. It does not rely on optimizations specific for the field the students are training in. Instead, it relies upon the configurability of DBpedia Spotlight and the broad coverage of professional topics that is used on LinkedIn. Advantages of keeping the method and implementation field-agnostic are the reproducibility of the experiments with students of other fields, and a greater potential to collaborate in the development of the necessary software.

We found that the method makes mistakes that may, however, be overcome with domain-specific optimizations. Abbreviations of field-specific concepts which are commonly used with a different meaning are not disambiguated correctly. We also found that the coverage of the vocabulary was too broad. For example, "Schizophrenia" is in most disciplines never a main topic.

Our results in estimating mastery levels are less promising. It is possible that we have used suitable indicators and that the used data transformations are not right for this task. A post-hoc analysis of our results can clarify this matter to some extent. It will be interesting to see if a method that is based on machine learning, but uses the same features as we have, will fare better in future research.

To make further advances in mastery profiling, we may have to turn to techniques that are outside the scope of the current method. Portfolio documents that were the product of teamwork inherently describe the actions of multiple team members. We would want to distinguish between individuals, and discern "who did what". For course descriptions it holds that not all text indicates what the students will do or learn. Administrative remarks say something about the course or about the teacher, but give no relevant information about the students who have completed the course. Such mistakes ask for more focus on textual relations, as is done in Open Information Extraction (Etzioni et al. 2011).

8 CONCLUSIONS

In this paper, we have presented a method that produces learner profiles on the basis of existing documents that are associated with students. It is able to link students to a large amount of topics, in which they have skill, knowledge, and/or interest, with high precision. We have not yet succeeded in estimating the mastery levels that students have in these topics. Our method can be used as a baseline in future experiments that aim to produce learner profiles from existing documents. We aim to publish our current implementation under an open source license to facilitate this.

Our work is also a demonstration of a novel application of entity linking. We have shown that DBpedia Spotlight can be configured to accurately annotate course descriptions, portfolio documents, and websites. A customized vocabulary was used to filter annotations that are relevant to the mastery profiling task, and to combine the annotations from Dutch and English language documents into a single learner profile. The sets of topics that were extracted from students' associated documents have been successfully expanded by inference over semantic and probabilistic relationships between topics.

We hope that the work that has been described in this paper can serve as a starting point for the inclusion of detailed task-related attributes in learner profiles and, more generally, that it will assist in the adoption of CSGF in higher education.

ACKNOWLEDGEMENTS

Many thanks go to Wouter Weerkamp for valuable guidance and feedback; to Flip van Haaren and Raymond Jelierse at Shareworks for feedback and technical assistance; to the participants for responding to the questionnaire and for reviewing their own learner models; and to Joachim Daiber for clarifying the configurability of DBpedia Spotlight.

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Analysis of Behaviors by Audience in Lectures by Using Time-series Models

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Keywords: Lecture, Speaker, Audience, Behavior, Time Series Model, Synchronization.

Abstract: In this paper, the dominant behaviors defined by the face direction of the speaker and audience in lectures are analyzed by using the time-series models. First, we detect the face region of the speaker and audience by the image processing and we adopt the number of skin-colored pixels in face region as features for behaviors by them. Next, we construct piecewise time series models for behaviors by the speaker and audience. Finally, we analyze the synchronization phenomena in speaker and audience by comparing time series models. Concretely, we show that the parameters in the time series models denote the dominant section in lectures. Moreover, we discuss the relationships among notes, test and behaviors by audience.

1 INTRODUCTION

In diary life and education field, it is very important for human conversation to analyze gaze points and eye movements (Land and Taters, 2009). However, speaker and teacher have to talk with many audience and grasp their interests for given contents immediately in lectures. Specifically, in lectures and classes, lecturing with monotonous speech and gestures lose sometimes audience and audience interests for given contents. Good teachers and speakers can judge how audience and audience can understand and have interests for given contents and speech based on their expressions.

Experimentally, they focus on the eye movement by audience and expressions for the purpose of judgement of taking interests in the communication. Moreover, teachers and speakers can change the contents and repeat the same contents with slower speed according to the behaviors by students and audience. In these cases, the lecturer and speaker move face around and look at faces of audience for the purpose of evaluation of understanding and interests by audience. On the other hand, audience communicate their interests to speaker by their eye contacts and expressions. It is very important to analyze the interaction between behaviors by both speaker and audience.

Iso has shown that gestures by speaker has strong relations with the skill of speech (Iso, 2011). Moreover, it is shown that the frequency of gestures have positive correlation with the skill of speech by the speaker. On the other hand, Hatakeyama et al. have discussed a case that speaker can not see the behavior of audience (Hatakeyama and Mori, 2001). They have investigated how this case influenced with the speech and behaviors by the speaker. Therefore, from the viewpoint of evaluation of the interest and the understanding of audience, it is very important to investigate the interaction between speaker and audience. Moreover, Marutani et al. have proposed a method for the detection of behavior by speaker by using multiple cameras in the lecture on-line (T. Marutani and Minoh, 2007).

In this paper, the dominant behaviors define by the face direction of the speaker and audience in lectures are analyzed by using the time-series models. Here, the dominant section and model mean the change of the contents by the speaker and interests by the audience. The contents (words, images, figures and speech) and gestures by speaker are communicated to audience in lectures. The understanding and interest by audience are transformed to behaviors by them and their behaviors are communicated to speaker. Here, the interpersonal communication between the speaker and audience with speech and gestures occurs. Authors have discussed the extraction of relationships between them by using multi-layered neural networks (E. Watanabe and Kohama, 2011b).

This paper can be summarized as follows; First, we detect the face region of the speaker and audience by the image processing and we adopt the number of skin-colored pixels in face region as features for behaviors by them. Next, we construct piecewise time series models for behaviors by the speaker and audience. Finally, we analyze the synchronization phenomena in speaker and audience by comparing with piecewise time series models. Concretely, we show that the parameters in the time series models denote the dominant section in lectures. Moreover, we discuss the relationships among notes, test and behaviors by audience.

2 ANALYSIS OF BEHAVIORS BY SPEAKER AND AUDIENCE

The speaker can communicate a lot of contents to audience by using words, figures, pictures, and speech information in lectures. Moreover, audience are sensitive to the behavior by the speaker including the loudness of the speech, the face and hand movements. On the other hand, the speaker can confirm the understanding and the interest of audience for given contents by asking questions on audience.

We focus on the intrapersonal communication in speaker and audience in this paper. The intrapersonal communication in lectures shows the changes of the face movement and the loudness of speech. Therefore, we extract the dominant rules in the intrapersonal communication by using piecewise time-series model.

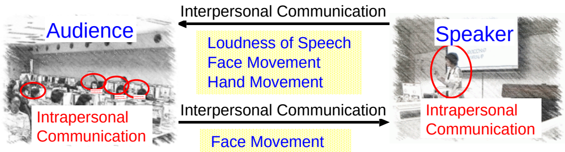


Figure 1: Interpersonal and intrapersonal communication for speaker and audience in lectures.

From Figure 1, we can summarize the following relations between behaviors by speaker and audience as follows;

- The influence of the behavior $x_S(t)$ by speaker on the p-th audience $x_A^p(t)$;
$$x_A^p(t) = f_{AS}(x_S(t-i), x_A^p(t-i)),$$
- The influence of the behavior $x_A^p(t)$ by p-th audience on audience $x_S(t)$;
$$x_S(t) = f_{SA}(x_S(t-i), x_A^p(t-i)),$$
- The intrapersonal communication in behavior $x_S(t)$ by speaker;
$$x_S(t) = f_S(x_S(t-i)),$$
- The intrapersonal communication in behaviors $x_A^p(t)$ by the p-th audience;
$$x_A^p(t) = f_A(x_A(t-i)).$$

In this paper, we treat the intrapersonal communication $x_A^p(t) = f_A(x_A(t-i))$ in behaviors $x_A^p(t)$ by the p-th audience.

2.1 Extraction of Features for Behaviors by Speaker and Audience

For the detection of the relations between behaviors by speaker and audience, we adopt the face movement as a feature. This feature can be extracted by image processing for images recorded by video camera.

Here, we detect the face region of the speaker and audience based on the color information. Moreover, the image for the face region has the skin-colored pixels. Therefore, we extract the skin-colored regions including face and hands based on the detection of pixels $\{f_{\mathrm{Red}}(x,y),\ f_{\mathrm{Green}}(x,y),\ f_{\mathrm{Blue}}(x,y)\}$ with the following conditions;

$$\begin{aligned} f_{\mathrm{Red}}(x,y) &> \varepsilon_{\mathrm{Red}}, \\ f_{\mathrm{Red}}(x,y) &> f_{\mathrm{Green}}(x,y) + \Delta_{\mathrm{Green}}, \\ f_{\mathrm{Red}}(x,y) &> f_{\mathrm{Blue}}(x,y) + \Delta_{\mathrm{Blue}}, \end{aligned} \tag{1}$$

where $\varepsilon_{\mathrm{Red}}$ denotes a threshold for the detection of the red-colored pixel. Also, Δ_{Green} and Δ_{Blue} denote thresholds for the evaluation of the objective pixel.

Figure 2 shows changes of the number of skin-colored pixels in the face region detected by image processing in a lecture. In this Figure, it is shown that the number of skin-colored pixels changes according to the position and direction of the face region.

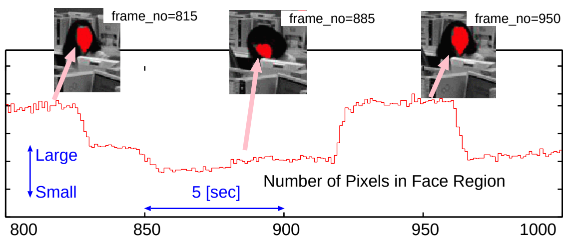


Figure 2: Changes of the number of skin-colored pixels in face region.

2.2 Analysis of Behaviors by Speaker and Audience by using Time-series Models

Features for the behavior by the speaker detected by image processing method can be summarized as follows; (i) the loudness of speech by speaker, (ii) the number of skin-colored pixels in the face region, and the number of skin-colored pixels in the face region of audience. In lectures, the speaker has to talk with many audience and grasp their interests for given contents immediately. Accordingly, they focus on the face movement by the audience for the purpose of judgement of taking interests in the lecture.

In this paper, we assume that the face direction by speaker and audience show non-stationary characteristics with the time. Namely, that characteristic of the behavior by the audience changes with the time and the content of the lecture. In this section, we propose an extraction method of "dominant section" and model for speaker and audience based piecewise AR (auto-regressive) modeling. Here, the "dominant section" and model mean the change of the contents by the speaker and interests by the audience. Therefore, it is very important for the analysis of the objective lecture to extract dominant section.

We assume that the face direction by speaker and audience can be modeled by the following non-stationary AR model with time varying parameters $a_i(t)$; Let us consider the following non-stationary AR model with time varying parameters $a_i(t)$;

$$x(t) + \sum_{i=1}^{p} a_i(t)x(t-i) = e(t), \tag{2}$$

where p denotes the degree of the AR model, and a sequence $\{e(t)\}$ of white noise has the following statistics:

$$E[e(t)] = 0, \;\; E[e(t)e(\tau)] = \sigma^2\delta_{t\tau}, \tag{3}$$

where $\delta_{t\tau}$ denotes the Kronecker delta function.

When the Yule-Walker method is applied to non-stationary time series data, we have to pay attention to the following trade-off problems; (i) Too long local section: While the reliability of the statistics becomes increased, it is difficult to grasp the changing property of time varying parameters. As a result, the estimation performance of such parameters becomes worse. (ii) Too short local section: In the contrast, while it is easy to grasp the changing property of time varying parameters, the reliability of the statistics becomes decreased.

It is very important to develop a modeling method by taking account of these non-stationary properties.

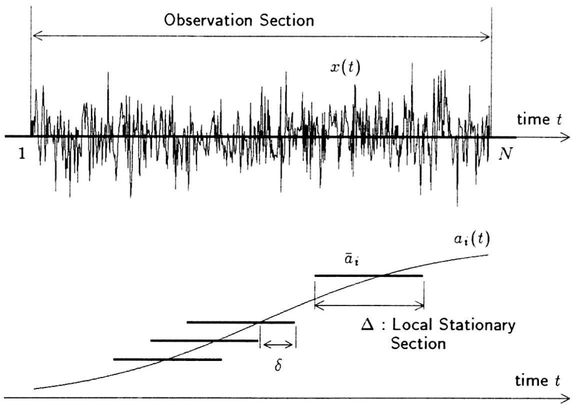


Figure 3: Observation section and local stationary section Δ in the non-stationary time-series data.

From the viewpoint of the statistical approach, several kinds of estimation methods of time varying parameters in AR model have been already discussed by many researchers. They can be categorized into the following two approaches: (i) Estimation method by introducing the local stationary section (Y. Miyanaga and Hatori, 1991), (Y. Miyoshi and Kakusho, 1987), (ii) Estimation method by introducing the time varying parameters (E. Watanabe and Mitani, 1997). In block-wise processing for the non-stationary time series data, it is necessary to consider three factors (i.e., the length of the local stationary section, the learning ability of the local stationary model, and the structure of the local stationary model). These factors are mutually connected and it is very difficult to determine appropriate values for such factors in prior.

In this paper, we propose a method for the extraction of "dominant section" and model for speaker and audience based on time-series models. Authors have already proposed an extraction method for the dominant sections based on the prediction error (E. Watanabe and Kohama, 2011a). Here, the dominant section and model mean the change of the contents by speaker and interests by audience. In this paper, we propose a new extraction method for the dominant sections based on the change of estimated parameters. The prediction value $\hat{x}(t)$ in the k-th local stationary section can be calculated by

$$\hat{x}(t) = -\sum_{i=1}^{p} a_i^k x(t-i), \tag{4}$$

where a_i^k denotes the estimated parameter in the k-th section. Also, the prediction error E_P^k in each section can be calculated by

$$E_P^k = \frac{1}{\Delta} \sum_{t=k\Delta}^{(k+1))\Delta} (x(t) - \hat{x}(t))^2. \tag{5}$$

When the prediction errors E_P^k in the k-th section and E_P^ℓ in the ℓ-the section are small and the estimated parameters a_i^k satisfy the following condition, the k-th and ℓ-th sections can be modeled by the same time-series model.

$$E_a^{k,\ell} = \frac{1}{P}\sum_{i=1}^{p}(\hat{a}_i^k - \hat{a}_i^\ell)^2 \leq \varepsilon_a, \qquad (6)$$

where ε_a denotes the threshold value. As shown in Figure 4, if the k-th and ℓ-th section have the same characteristics, that is, the behaviors by the speaker and audience, we can model the above two sections with same time-series model. Therefore, the behaviors by the speaker and the audience in the k-th and ℓ-th sections can be modeled by the same time-series model.

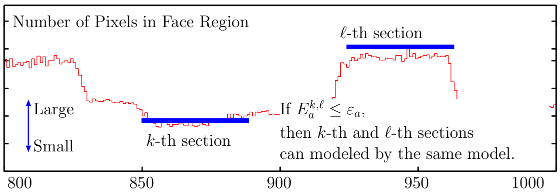


Figure 4: Observation section and local stationary section Δ in the non-stationary time-series data.

On the other hand, if $E_a^{k,\ell}$ is greater than ε, the k-th and ℓ-th sections can not be modeled by the same time-series model. When the number of local sections are large, the objective local sections can be modeled by a dominant time-series model.

3 ANALYSIS RESULTS

3.1 For Artificial Data

First, we consider the following non-stationary AR model with time-varying parameters $a_i(t)$:

$$x(t) + \sum_{i=1}^{2} a_i(t)x(t-i) = e(t). \qquad (7)$$

We assume that time-varying parameters $a_i(t)$ changes with time t as follows:

$$\begin{cases} a_1(t) = 0.5, a_2(t) = -0.2, \\ \quad (1 \leq t \leq 150, 301 \leq t \leq 450), \\ a_1(t) = -0.5, a_2(t) = 0.2, (\text{otherwise}). \end{cases} \qquad (8)$$

Here, the prediction error E_P and the estimated error E_a for time-varying parameters can be evaluated by the following equations;

$$E_P = \frac{1}{N}\sum_{t=1}^{N}(x(t) - \hat{x}(t))^2,$$

$$E_a = \frac{1}{2N}\sum_{t=1}^{N}\sum_{i=1}^{2}(a_i(t) - \hat{a}_i(t))^2,$$

where $\hat{x}(t)$ and $\hat{a}_i(t)$ denote the predicted value and the estimated parameter respectively. Figure 5 shows the prediction error E_P and the estimated error E_a for time-varying parameters with various Δ for artificial time-series data. As shown in Figure 5, when Δ becomes smaller, the prediction error E_P and the estimated error E_a for time-varying parameters can be improved.

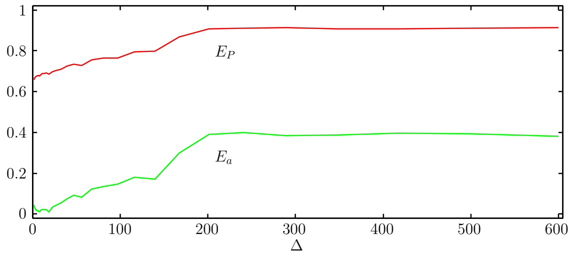


Figure 5: Prediction error E_P and estimated error E_a for time-varying parameters with various Δ for artificial time-series data.

Moreover, Figure 6 shows the estimated parameters $\{\hat{a}_i(t)\}$ for $\Delta = 10, 600$. In case of $\Delta = 10$, the estimated parameters $\{\hat{a}_i(t)\}$ can catch up the characteristic for parameters $\{a_i(t)\}$. Therefore, we adopt the shorter local section Δ as modeling the time-series model with time-varying parameters.

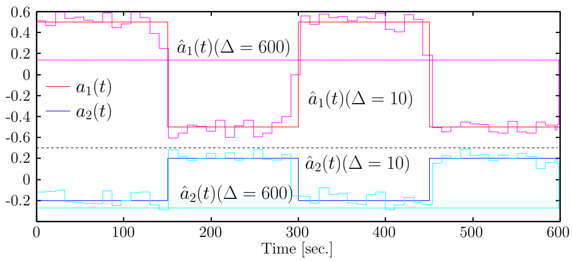


Figure 6: Estimated parameters $\{\hat{a}_i(t)\}$ for $\Delta = 10, 600$.

3.2 For Real Data

We have recorded images and speech for speaker and audience in a lecture concerning on “C language”. In this lecture, the speaker explained “the role of the pointer” during about 20 [min].

As shown in Figure 7, four audience (21-22 years old) had this lecture and the images for speaker and audience were recorded by digital video cameras. These images were recorded by the rate 10 [fps] and the size of 640×360 [pixels].

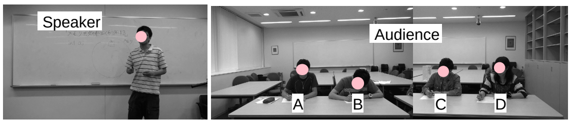


Figure 7: Speaker and audience recorded by digital video cameras.

Moreover, in Figure 8, the transition of behaviors (speaking and silent) by speaker is shown. In "Silent" phase, the speaker is waiting for finishing of taking notes by audience.

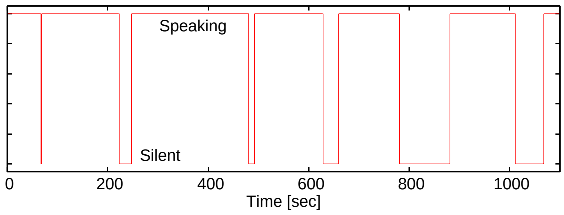


Figure 8: Behaviors (speaking and silent) by speaker.

3.2.1 Features by Speaker and Audience

In this paper, we adopt the number of skin-colored pixels in the face region as the feature for the behaviors by speaker and audience. Figure 9 shows the numbers of skin-colored pixels in speaker and audience.

When the value by the speaker is small, the speaker is writing the content on the whiteboard. On the other hand, when the value by the speaker is large, the speaker is turning the face to audience. When the value by audience is small, the audience is writing the content on the note. Furthermore, when the value by audience is large, the audience is turning the face to the speaker. From Figure 9, we can see that the behaviors by audience-C and audience-D have high correlation each other.

3.2.2 Prediction Error and Estimated Parameters

Figure 10 shows the prediction error E_P and estimated parameters $\{\hat{a}_i(t)\}$ in each section for audience-A. Here, the length Δ of the local stationary section is set as 10 [sec].

In Figure 10 (a), we have the sections with large prediction error at 230, 340, 900 and 1,070 [sec]. On the other hand, prediction errors in other sections are smaller than 0.1. Therefore, we can confirm that the behaviors by audience-A can be modeled by the piecewise auto regressive models with adequate precision. Moreover, Figure 10 (b) shows the estimated parameters $\{\hat{a}_i(t)\}$ in each local section defined by Δ.

For example, the change of estimated parameters is small in the section [780,820] and this section can be classified to the same time-series model by the condition Eq. (6).

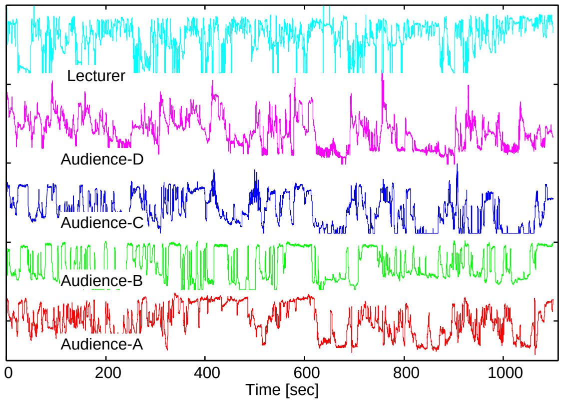
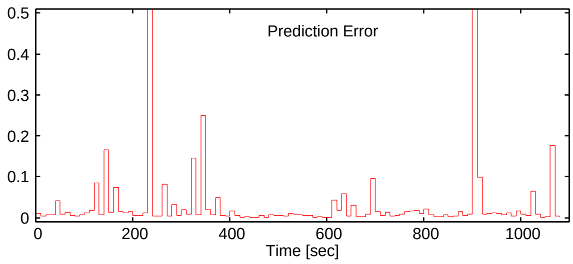
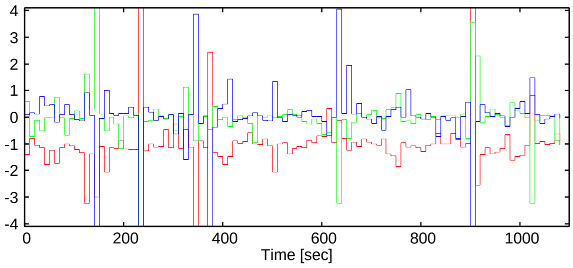


Figure 9: The numbers of skin-colored pixels in speaker and audience.



(a) Prediction Error E_P



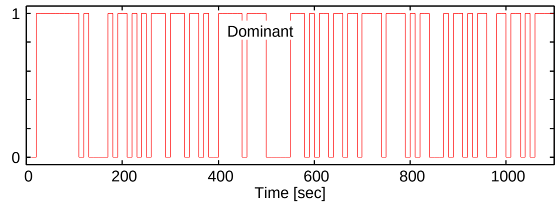
(b) Estimated Parameters $\{\hat{a}_i(t)\}$

Figure 10: Prediction error E_P and estimated parameters $\{\hat{a}_i(t)\}$ in each section for audience-A.

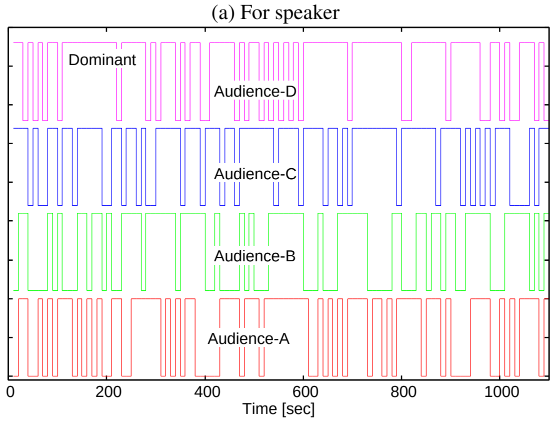
3.2.3 Extraction of Dominant Time-series Model

Figure 11 shows the sections modeled by the dominant time-series models for behaviors by speaker and audience. Here, the value "1" denotes that the objective section defined by Δ can be modeled by the dominant time-series model.

In Figure 11 (a), we can see that the number of the dominant time-series models by speaker is small. Because the speaker has to pay attention to all audience and he often is turning the face here and there. On the other hand, in Figure 11 (b), we can see that the numbers of the dominant time-series models by audience are large. Especially, the changes by audience-C and audience-D are very similar in the section [600,900].



(a) For speaker



(b) For audience

Figure 11: Changes of the dominant time-series models by speaker and audience.

From this figure, we can see that the synchronization phenomena occurs in audience-C and audience-D by comparing time series models. Furthermore, we evaluated hand-written notes by all audience after lecture and hand-written notes by audience-C and audience-D had good contents compared with other audience.

4 CONCLUSIONS

This paper have discussed the analysis of behaviors by speaker and audience in lectures. First, we have extracted the face direction as behaviors by speaker and audience. Next, we have constructed piecewise time-series models for their behaviors. Finally, we have shown the estimated results of dominant sections in a real lecture based on the piecewise time-series models. From experimental results, we have shown that the synchronization phenomena in two audience as shown in Figure 11 and the hand-written notes by the two audience had good contents compared with other audience.

As future work, we would like to discuss many cases with many audience and speakers. Moreover, we would like to analyze the eye movement by the speaker for the purpose of detection of the key person in audience.

ACKNOWLEDGEMENT

This work has been partly supported by the Grant-in-Aid for Scientific Research (C) from the Japan Society for the Promotion of Science (Grant No. 25350308).

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Learn and Evolve the Domain Model in Intelligent Tutoring Systems
Approach Based on Interaction Traces

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Keywords: Adaptive Learning System, Bayesian Student Model, Clustering, Interaction Traces.

Abstract: Majority of the systems developed in the field of education aim to tailor information presented to their users according to them as efficiently as possible. Often these systems use a User Model, a Domain Model and an Interaction Model to provide the adaptation/personalization effect. However, any deficiencies in these models directly influence the quality of adaptation the system provides. In order to address this issue, we propose to use modeled user's interaction traces to detect these deficiencies in the domain model. Furthermore, the use of these interaction traces will help us in proposing a more correct domain model according to the user's competence. We had tested our approach by creating an educational system. The overlay modeling approach is used with Bayesian Networks to model our domain model. The results of the conducted experiments are also presented in this article.

1 INTRODUCTION

Adaptive computer based educational systems aim to provide personalized education to their users. The quality of the adaptation depends directly upon the quality of the educational domain's knowledge modelling in the system. Since, knowledge modelling is not a straight forward task, therefore it is sometimes necessary to update the system's knowledge about the educational domain. This updating of knowledge can be performed manually (by a human expert), automatically (by machine learning), or semi-automatically (using machine learning to help human expert).

Our research focuses on the problem of semi-automatically finding improvements in the Domain Model[1] of a computer based educational system via data-mining, and proposing these improvements to the system's domain expert[2].

Data-mining is the process of extracting information from a raw dataset and transforming it to knowledge. Researchers have made use of data-mining in various educational settings for different objectives (Bhise et al., 2013). (Baker, 2010) have identified four key areas data-mining application in education, they are: improving student models, improving domain models, studying the pedagogical support provided by learning software, and scientific research into learning and learners.

In our research we focus on the type of educational systems generally referred to as Intelligent Tutoring System (ITS) (Burns, H. L. And Capps, 1988) or Adaptive Hypermedia Systems (AHS) (Brusilovsky, 1996) in literature.

Many of these systems follow the architecture proposed by (Benyon and Murray, 1993). They have identified the most important components of an ITS, they are

1. User Model: represents the system's belief about the user, particularly: psychological model, profile model and student model.
2. Domain Model: defines the aspects of the system and the world that are important for inferences, e.g., knowledge about the domain, teaching resources, functions that might be altered.
3. Interaction Model: handles the dialogue between the user and the application for adaptation of the system to the user properties taking into account the domain model.

[1] In this article, domain model refers to the description of the various concepts of an educational domain and the relation between them. For example, for the educational domain of Mathematics the concepts could be 'Addition', 'Subtraction', etc.

[2] A domain expert is a person who defines the education domain model of an educational system.

In our research, we propose to represent the users' interaction history as modelled interaction traces (Clauzel et al., 2011). The interaction traces are defined as a history of learner's actions collected, in real time, from his/her interaction with a computer system. We have applied the data-mining process to these modelled interaction traces to discover new knowledge about the domain model. Afterwards, this knowledge is presented to the domain expert, who can make "if" necessary adjustments/modifications to the domain model. These adjustments can have a positive effect on the educational quality of the system. These improvements could include: identifying the exercises or educational resources that are not related to the correct concept, proposing to merge two different concepts, and splitting a concept into further new concepts.

To test our approach we have created an adaptive computer based education system. We have used overlay modelling using Bayesian Network (BN) (Pearl, 1988) to model our user and domain model. The use of BNs to manage uncertainty in user models has been investigated and championed by (Conati et al., 2002). In our system, the user model is updated by the propagation of values in the BN.

Many approaches have been proposed to update the domain model using the users' logs. (Jr et al., 2009) used learning factor transfers and Q-matrices to generate domain models that maximizes learning via item sequencing. Similarly, BNs have been used extensively to model student/user models, (Sande, 2013) used BNs to trace student performance. Clustering techniques have been also employed to group students into different categories, (Xu et al., 2013) compared the efficiency two clustering techniques in educational systems. (Shen et al., 2003) used clustering and case-based reasoning to personalize the learning process of students. (Retalis and Papasalouros, 2006) proposed a tool that employs clustering to help instructors to learner's progress and make amendments to the teaching strategy if necessary. Clustering with other techniques have been employed by (Chen and Chen, 2009) to provide formative assessment of students to teachers. Domain concept similarity was measured in (MADHYASTHA and HUNT, 2009) using mining techniques on students' assessment data. Along with these many other approaches have been employed to either discover new concepts, and or cluster students (Lee et al., 2009).

Although, many systems try to update the domain model in different ways. However, none of them use modelled interaction traces as knowledge sources for the data-mining process. Our approach, unlike others, models the user's interaction traces, and use them to update the domain model, while also using the same traces to update the user profile.

The remainder of the article is organized as follows. Section 2 gives the general architecture of our system. Section 3 gives the details about the representation of the domain knowledge and user profile. Section 4 shows the updating process of domain knowledge and user profile. Section 5 shows the simulation we conducted with our approach and results we obtained. We finish by our concluding remarks and perspectives.

2 GENERAL ARCHITECTURE

In order to bring flexibility and adaptability in supporting individualized learning, the system must follow the progress made by each user in order to propose relevant information to his needs and skills. For this, the proposed architecture includes control loops, both *in on-line* for the adaptation of the scenario based on user's behaviour, and *in off-line* for updating domain knowledge and user profile based on the interaction traces.

Our system's architecture is depicted in the Fig 1. It has six modules: the domain model/knowledge, the user profile, the reasoning, the interactions management, the interaction traces base and the traces management module.

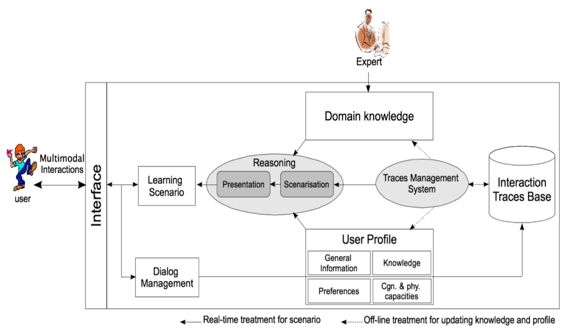

Figure 1: General architecture.

Initially, the domain expert feeds the system with domain knowledge about an educational domain and characterizes the user profile (in some application context, the user profile can be defined by the user himself). The reasoning module uses the user profile and domain model, in real-time, to generate learning scenarios adapted to the user and his educational goals. We define a learning scenario as an ordered sequence of learning activities and exercises that helps the user to achieve an educational goal.

During the interaction between the user and the scenario, all the user actions are collected by the interactions management module, where they are modelled as modelled interaction traces. The traces management module use them, in off-line mode, to update the domain knowledge and the user profile.

The following paragraphs give a short overview of each module :

Domain Model/Knowledge: contains all characteristics of the knowledge to teach an educational domain. It consists in storing information on topics/concepts, exercises, problems and relationships between them. This knowledge, represented as an extended Bayesian network, is used by the reasoning module for the generation of learning scenarios. The Sec 3 gives more details on the representation of knowledge.

User Profile/Model: represents and manages all important information about the user/student, which can aide in the learning process. All these information are represented as a set of pairs <*attribute, value*>, where *value* can be discrete or probabilistic. For example,<age, 23>, <Math, 70.0>, etc.

Reasoning: the purpose of this module is twofold. Firstly, to generate adaptive scenarios according to the user's profile and domain knowledge via *The Recommender* sub-module. Secondly, to tailor the presentation of the scenarios selected by the recommender according to the user's profile via the *The Presentation Adapter* sub-module.

Interactions Management: is responsible to log all the user's actions (responses to questions, response time, time consumed while consulting help, type of device used by the user to interact with the system etc.) in a modelled trace(see Sec 4.1). The Traces Management module access them in order to learn new knowledge about the user.

Interaction Traces Base: this is where the users' modelled interaction traces are stored.

Traces Management: is responsible to update the domain knowledge and user profile using the users' traces. The reasoning performed by this module takes place off-line i.e. the User Profile and Domain knowledge are updated only when the user logs out. The section 4.1 gives the traces representation and the reasoning process adopted by this module.

In the next section we show the modelling of the domain knowledge and user profile.

3 REPRESENTATION OF DOMAIN KNOWLEDGE AND USER PROFILE

The domain knowledge is modelled via a domain model. The domain model defines the concepts needed to describe the educational domain. The topics/concepts in the domain model are interconnected to form a hierarchy. We have used the overlay Modelling approach to model the domain model. Overlay models need association with a statistical model to infer user's knowledge (Nguyen and Do, 2009). Therefore, we used Bayesian Networks (BN), they are the best choice as shown by (Brusilovsky and Millán, 2007), because they allows to represent and infer the uncertainty in the user's knowledge.

Our domain model is an extended Bayesian Network(BN) whose nodes represent the concepts to teach and links represent hierarchical relationships between the concepts. Wherever necessary the general concepts are further divided into more specific sub-concepts. The conditional probabilities of the BN are defined by the domain expert[3]. Figure 2 shows an example a domain model, in which:

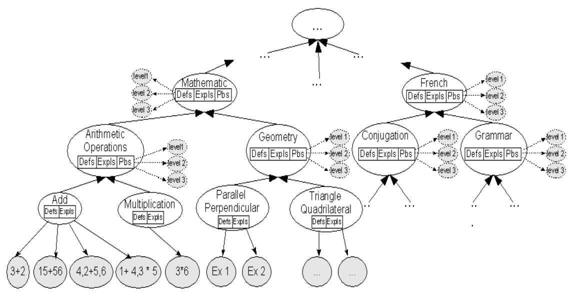

Figure 2: Extended Bayesian Network Representing Domain Knowledge.

1. Concepts of the domain, represented by circles on a white background, represent the atomic elements of knowledge about given topics. In the knowledge tree, each concept is divided into sub-concepts, and these into other sub-concepts, and so on. At the same time, each concept of the network contains sets of definitions and examples related to the topic. These elements are in several formats (text, image, video, etc.).

2. Evidences or observation, represented by circles on a grey background, are the leaves of the tree. The observations are exercises and problems related to the concepts which they are linked. These

[3]The conditional probabilities can also be learned automatically via different techniques but they are beyond the scope of our research.

exercises and problems are used for the creation of the tests.

Indeed, we distinguish between problems and exercises as shown in several studies in the learning field. An exercise can be defined as an activity that is performed as a test or practice of one's technical skill. If the students know how to perform and know the steps involved in reaching a solution, then they are performing an exercise. It is noted that the exercises can be hard (Singh and Lau, 2006), but they are never puzzling, for it is always immediately clear how to proceed and solve a problem algorithmically by recognition, recall and reproduction. Problems are something completely different. It is a question that, on the one hand, concerns several concepts in relation (Bair et al., 2000), on the other hand, the solution requires a procedure not immediately apparent. It consists in putting the student in an original situation that requires him to put together several concepts to find new results for him.

We therefore distinguish two types of evidence variables, namely:

1. Exercises: these are evidences associated with simple concepts (i.e. not containing sub-concepts). For example, the evidences of the concept "Add" concern exercises of addition concept.
2. Problems: these are evidences associated with concepts containing sub-concepts. The evidence in this case must concerns the concept in question and all its sub-concepts. For example, the evidences of the concept "Arithmetic Operations" are problems that deal with both addition and multiplication.

Since we are using an overlay approach, the user model contains the probabilities of the user's mastery of different concepts in the domain model. For example, a particular user model may contain a value "$<$ "Math", 75.0 $>$, indicating that the probability that the user knows the concept "Math" is 75%.

The updating of the domain model consists of adding or deleting the concepts and/or the relations between the concepts in the BN, and the updating of the user profile consists of calculating the probabilities of the variables of the network according to the observations. Recall that the user profile is represented by a vector of components of the form $<$*attribute, value*$>$ where the attributes corresponds to the variables of the network (concepts of domain knowledge), and the values correspond to the probabilities of the variables of the network (estimation of the user's mastery of concepts).

The next section presents the strategy we have adopted to update the domain knowledge and the user profile.

4 UPDATING OF DOMAIN KNOWLEDGE AND USER PROFILE

The Fig.3 gives the principle of our approach for updating the domain knowledge and the user profile. Initially, the expert defines a domain knowledge in the form of an Extended Bayesian Network presented in the section 3. Thereafter, the reasoning module uses this knowledge to generate leaning scenarios to the user taking into account his profile. In the learning session, all the actions of the user on each scenario tests are stored in the form of modelled interaction traces. So, each user has a trace base representing all his interactions in different sessions. Our strategy consists in using theses traces as knowledge source in order to update both the domain knowledge and the user profile.

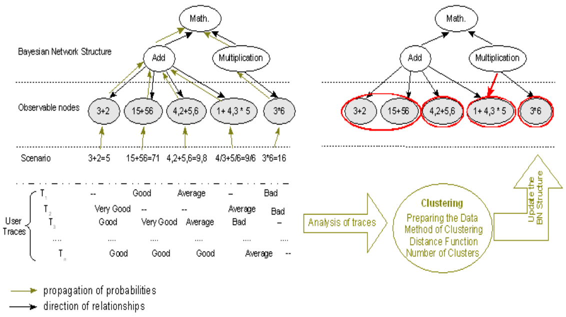

Figure 3: Domain Knowledge's and User Profile's updating process.

To update the user profile, the idea consists in using Baye's formula (cf Sec 4.2) for the propagation of information in the network. For the updating of domain knowledge, the principle is to categorize the observed elements of the trace using a method of clustering. The results of the clustering are then presented to the expert who can then update the structure of the Domain Model according to the results.

Firstly, this section presents the model adopted for the formalization of traces of interaction. Secondly, we present the strategy for updating the user profile. Finally, we detail the method of updating domain knowledge.

4.1 Formalization of Traces

A trace is the result of the interaction between the user actions and the scenario tests, where the scenario tests are created by the reasoning module. Each session is associated to a trace. A trace is a sequence of observed elements representing the user actions on the elements of tests scenario (exercises and/or problems). Formally, a trace T is represented as follows: T=$< O_1, O_2, ..., O_n >$ Where each observed element O_i is characterized by the following quintuple : O_i = <Q,R,T,S,E>

Q : Exercise / Problem (Evidence/Observation node of BN)

R : Response of user

T : Response time : time elapsed during the display of the question and the response of the user.

S : Correct solution of question, and

E : Evaluation of user response.

E is a function f that calculate the gap between the user response and the correct response. This function takes into account also the total time that he/she spent to answer the question **Q**. The values of this function f are defined in the interval [0,1] where: 0 indicates that the student does not know the concept, and 1 indicates that the concept has been correctly learned. In order to simplify, we use this classification:

1. If 0.1 $\geq$ f $\geq$ 0 then E = Very Bad
2. If 0.3 $\geq$ f $>$ 0.1 then E = Bad
3. If 0.6 $\geq$ f $>$0.3 then E = Average
4. If 0.8 $\geq$ f $>$ 0.6 then E = Good
5. If 1 $\geq$ f $>$ 0.8 then E = Very Good

4.2 Updating User Profile

The probabilities associated with each concept of the BN represent the mastery achieved by the user of that concept. The response of the user i.e. a correct response of an exercise of a concept given in relatively quick time, with little or no help will increase the probability of the user knowing that particular concept. Similarly, an incorrect response will decrease the probability of the user knowing that particular concept. This updating of the probabilities from the evaluation of user's responses is done by the use of Baye's Rule.

Let A = $\{A_1, A_2, ..., A_i\}$ be the set of observations related to the topic B then[4] :

$$P(A|B) = \frac{P(B|A) * P(A)}{\sum_i P(B|A_i) * P(A_i)} \quad (1)$$

[4]Note: The same formula is used in the propagation of probabilities between concepts.

4.3 Updating Domain Knowledge

Recall that the principle of updating domain knowledge is to semi-automatically find new concepts and links in the domain model, which can help in increasing the quality of the domain model. This in terms of BN means learning or finding new hidden nodes in the network. For BNs there exists many techniques to facilitate hidden nodes learning (Neapolitan, 2003). These techniques are primarily based upon statistical methods. Unfortunately, for us these techniques are not feasible as they do not perform well on small sized data set. And we don't know a priori how large the data set will be. To counter this problem, we found out that *Clustering Algorithms* are more appropriate for our purpose. Since they can perform reasonably on small-sized data-set as well. It consists in using these algorithms on the observed elements of the trace in order to identify new concepts and relationships that emerge. That is to cluster the observations according to the value of the function f.

There are many algorithms to do clustering[5]. We experimented with K-Means algorithm and found it to be adequate enough to test and validate our approach. To perform clustering, we follow the following steps:

1. Preparing the Data: Make the data compatible to be presented to the clustering algorithm. We present the data in the form of a matrix. Where, the rows are observations and columns are the traces. If we take Fig.3 for reference, then the matrix will be like.

Evidences	Trace 1	Trace 2	Trace N
3 + 2	Good	Very Good	–
15 + 56	–	Very Good	Good
4.2 + 5.6	Bad	Very Bad	Bad
1 + 4.3*5	–	–	Average

   Where '–' represents missing values. We handle missing values by defining rules.
2. Choosing a Distance Function : Select a function to measure the proximity of two records. We had selected Manhattan Distance
3. Number of Clusters : To automatically determine the number of classes after analysing the traces. We had used K-Means with different values of K and chosen the value of K which gives the best result.

After the clustering is performed, we will have different exercises/problems of a concept divided in dif-

[5]A detailed comparative study of different clustering algorithms is out of the scope of our research.

ferent clusters. These clusters represent the new concepts in the Domain Model. These clusters show how the domain model could be organized according to a particular user. Once we have the clusters, we present the findings to the domain expert, who can validate the results and update the domain model accordingly.

5 SIMULATION AND RESULTS

To validate our approach we performed experiments. To show the generic nature of our approach we have decided to conduct our experiments for a course of JAVA programming language[6]. The domain model of this course is constructed by consulting the tutorial provided by Sun Microsystems. This tutorial is publicly available on internet [7]. Since, we didn't had access to real-world classrooms; we decided to use simulated users for our experiments. The use of simulated students have been done in numerous studies. (Iglesias et al., 2008) used simulated student clusters to simulate student behaviour.

The original concept tree for the tutorial of JAVA programming language is shown below[8] in Fig.4.

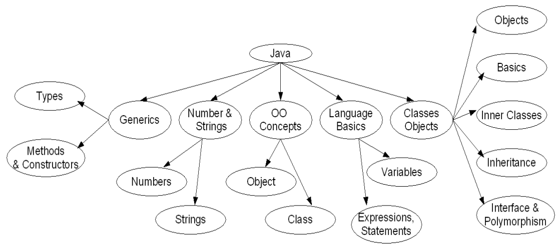

Figure 4: Actual Model of Java Tutorial.

There are plenty of concepts in this concept tree. In this article we have only concentrated on the concept 'Classes & Objects' [9]. Though, in the original tutorial the concept 'Classes & Objects' is well classified into sub-concepts such as interface, inner classes etc. For our experimentation we deliberately haven't classified the concept 'Classes & Objects' i.e. more than one sub-concept of 'Classes & Objects' is merged into a single concept 'Classes' in our domain model (The domain model represented in the form of Bayesian Network of our system with the modifications is shown in Fig.5). This is done deliberately to replicate the behaviour of an expert who either didn't consider it important for the course or had made an error in the classification. This means that the scenarization module will consider all the exercises/problems of the concept 'Classes' of the same difficulty, which is not the case. The sub-concepts of 'Classes' varies in difficulty for e.g the sub-concept 'Object' is much easier than the subconcept 'Interface & Polymorphism'. The assumption made by the scenarization module will cause problem for some users(not having sufficient knowledge) as the exercises/problems will not be presented to them in a progressive manner. This will result in either loss of the user's interest or inhibited learning.

For our experiments, we have decided to create three profiles of users. Each profile will have its own characteristics and competencies. These profiles are created to model the real world, where often users in the same group have different competencies and characteristics. Since, here we are dealing with a programming course for JAVA language; and in the paradigm of JAVA we are dealing specifically with the concept 'Classes'. These profiles are created keeping in mind the different competencies of the users in JAVA[10]. The characteristics of each profile are shown below

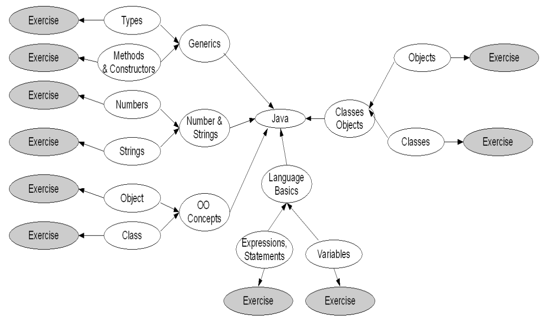

Figure 5: Modified Model of Java Tutorial.

1. *Profile 1:* basic users of JAVA language; they know the language fundamentals of JAVA.
2. *Profile 2:* knows the language fundamentals and also the basics of the concept 'Classes' of JAVA but not the advanced topics of 'Classes' like inner classes, Annotations etc
3. *Profile 3:* are advanced users with background knowledge of a high-level language. They also

[6]Although, we have chosen JAVA but we could have chosen any educational domain that can be represented via concepts and relations/links between those concepts. For example, Mathematics, Physics, Chemistry, English Language, etc.

[7]@ http://java.sun.com/docs/books/tutorial/.

[8]In this figure only partial tree is shown.

[9]Though, we are concentrating on only one concept, the process remains the same irrespective of the number of concepts involved in the process

[10]These profiles are constructed after consultation with a domain expert in JAVA. Different profiles may have resulted in different clusters, however, the process would have remained the same.

knows the advanced sub-concepts of the concept 'Classes'

After the profiles are created, we defined the scenarios for the course. The scenarios, as mentioned before, can be either created by an expert or they can be automatically created by the scenarization module. For our study we had defined the scenarios manually. We had selected 25 exercises. These exercises covers 4 sub-concepts of the concept 'Classes'. The distribution of the exercises is shown below

1. Question 1 - 6: belongs to the type 'Basic Questions'
2. Question 7 - 14: belongs to the type 'Inheritance'
3. Question 15 - 20: belongs to the type 'Interface and Polymorphism'
4. Question 21 - 25: belongs to the type 'Inner Classes'

We had created three scenarios for the concept and each scenario contains 10 exercises. Each scenario contains exercises from all four sub-concepts.

After the creation of scenarios, we presented them to the users of each profile. As a result of the interaction between the user and the scenarios traces are generated. These traces are saved in our trace base module. Afterwards, we performed clustering on the traces to discover knowledge. As mentioned earlier, before performing clustering the traces needed to be transformed in the form of matrix. The matrices for the three profiles after transforming and handling missing values are shown below.

Profile 1

Observations	Scenario 1	Scenario 2	Scenario 3
1	Good	Good	Very Good
11	Very Bad	Bad	Very Bad
19	Very Bad	Very Bad	Very Bad
25	Very Bad	Very Bad	Very Bad

Profile 2

Observations	Scenario 1	Scenario 2	Scenario 3
1	Very Good	Very Good	Very Good
11	Good	Very Good	Good
19	Average	Average	Average
25	Bad	Bad	Bad

Profile 3

Observations	Scenario 1	Scenario 2	Scenario 3
1	Very Good	Very Good	Very Good
11	Very Good	Very Good	Very Good
19	Very Good	Very Good	Very Good
25	Average	Average	Average

Clustering was performed after transforming the traces. The results of clustering are shown below:

Profile 1

Cluster No	Results
1	Questions belonging to category 'Basic Questions. Ex Question 1
2	All other questions. Ex Question 11, 19, 25

Profile 2

Cluster No	Results
1	All Questions of 'Basic Questions' and 'Inheritance. Ex Question 1, 11
2	Some questions of 'Interface and Polymorphism'. Ex Question 17
3	Remaining questions of 'Interface and Polymorphism' and all questions of 'Inner Classes'. Ex Question 19, 25

Profile 3

Cluster No	Results
1	All Questions of 'Basic Questions' and 'Inheritance', 4 questions of Inner Classes, 5 questions of 'Interface and Polymorphism'. Ex Question 1, 11
2	Remaining questions of 'Interface and Polymorphism' and 'Inner Classes'. Ex Question 20, 25

Figure 6 shows the final configuration of the domain model for each of the three profiles. In the figure, for 'Profile 1' the clustering process have made a separate cluster for the 'Basic Questions' and the rest of the questions are clustered separately. This goes well with our initial hypothesis that a user of basic qualification (Profile 1) will not be able to solve the questions of advanced concepts. These clustering results might prompt the expert to break the original concept of 'Classes' into two different 'Sub-Concepts' of 'Basic Concept' and 'Advanced Concepts.'

Similarly, if the domain expert analyse all the results of different profiles, s/he might be able to come up with a domain model that will further enhance the learning experience of users.

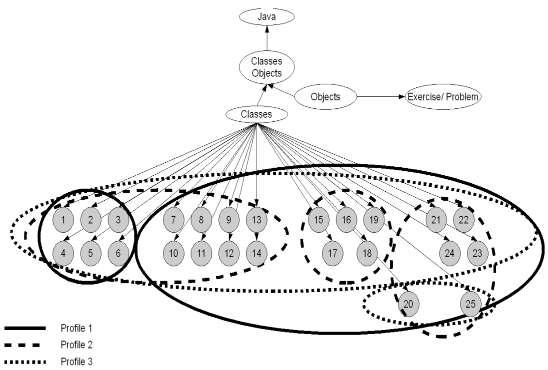

Figure 6: The resulting structure of the original Domain Model of the three profiles after clustering.

6 CONCLUSION

In this paper, we presented an approach to semi-automatically update the domain model using modelled interaction traces as knowledge sources in computer based educational systems.

We have used clustering to search for new knowledge in the domain model, afterwards, we present this knowledge to the domain expert who can then decide to incorporate this knowledge in the domain model or not. The quality of clustering results depends upon the different parameters of the clustering algorithm. To help the expert with different clustering algorithms, we have allowed the expert to select different parameters via an easy-to-use GUI in our system[11]. However, the choice of clustering algorithms or different parameters do not effect on the general working of the system/approach.

We also tested our approach with simulated users. The results obtained showed that our work is valid. Although, we acknowledge that different profiles could have resulted in different results. However, our approach would not have been changes as a result.

We have also published papers about the scenarization module. This module adaptively selects learning activities for a user according to his educational goals and user profile. We will definitely test our apporach with real-users. This will further cement the scientific standing of our approach.

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[11]The implemented system has not been presented in this article.

A Learning System Based on Learner Profile

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Keywords: e-Learning, Learning Style, Learning Object, Learner Profile, SCORM.

Abstract: The main purpose of e-learning systems is to provide learning materials through Internet to let learners upgrade their knowledge. To be more efficient, these systems must be able to present their learning materials based on learners' acquired knowledge as well as their learning capabilities (learning styles). Therefore, their development should be based on pedagogical models that make them able to adapt their learning materials on the bases of learners' competences (acquired knowledge and learning capabilities). This paper proposes a model and architecture of a learning system able to support pedagogical concepts such as learning styles and pre-requisite competences to adapt learning materials to learners based on their profiles.

1 INTRODUCTION

To improve their knowledge, many people use existing e-learning systems such as Moodle (Moodle). Unfortunately, these platforms don't offer learners' centred courses; therefore, most of the time, learners don't find a suitable ways of learning (learning style). It is noticed also that, the current platforms don't give much importance to the pedagogical side of the learning process; this can be seen through the used metadata model descriptor such as SCORM (ADL, 2009). However, many experimental research (Kolb D., 1984), (Chartier D., 2003) have noted that taking into consideration the pedagogical side of the learning process leads to better results. Furthermore, these researches led by these psychologists (Kolb D., 1984) (Chartier D., 2003) explain that school failure is mainly due to the lack of consideration of learning's styles which differs from one individual to another. Daniel Chartier (Chartier D., 2003) has also noticed that different learners have different ways of learning (learning style). Their success or their failure is thus related not only to the efficiency level, but also, to the ways they perceive, store and restore the information, how they build their knowledge bases. Individual human don't have the same competencies for acquiring knowledge.

Hence, the pedagogy sides of learning process must be introduced in learning systems to improve learners' results. This may be done by supplying learning systems with some reasoning capabilities to enable them to use the learner's learning style to adapt the learning process. Therefore, the description metadata model of learning object must be supplied with items that let Authors (Expert) to introduce pedagogical items within courses' descriptors, such as learning styles, pre-requisites courses and so on. These items can then be used by learning systems to generate adapted courses based on captured learners' profiles.

Being the most used learning system, we consider that SCORM LOM (IEEE, 2001) is the most appropriate learning object metadata descriptor to be extended to describe pedagogical items and particularly learning styles. This standard emerged among many others to allow reusability of educational objects and interoperability between developed learning systems. It happens that, these characteristics (re-usability and interoperability) are not enough to support learners' pedagogical profile such as learning styles. This limitation has been discussed in many research papers since the apparition of SCORM in 2000 with SCORM V1.0, modified in 2001 to SCORM V1.2 (ADL, 2001), then in 2004 to SCORM 2004 3rd edition V1.0 (ADL, 2006) and finally in 2009 to SCORM 2004 4th edition V1.1 (ADL, 2009). Referring to (ADL, 2009), SCORM LOM can be extended whenever the core set of metadata elements defined by LOM is not adequate enough to describe SCORM Content Model Components. SCORM allows two types of extensions' mechanism within the LOM which are:

- XML element extensions: it is permitted to add additional elements to metadata instances;
- Vocabulary extensions: list of vocabulary value proposed by the IEEE of the LOM.

Mason R.T. and Ellis T.J. (Mason R.T. and Ellis T.J., 2009) expose an approach to extend SCORM LOM with additional metadata to support adaptive learning. Baldoni M. & al. (Baldoni M. & al., 2004) propose to use ontology to add knowledge level to SCORM LOM. Milosevic D. and Brkovic M. propose as well to use ontology to expend SCOs Metadata in terms of pre-requisites (Milosevic D. and Brkovic M. ,2007).

Therefore, our objectif is to take benefit of this feature to design an adaptive learning system based on learning style. That means that a course can be planned differently according to learners' learning style. This planification will be use the different versions of the same course that have been prepared by experts for each leaning style.

This paper presents the concept of learning styles as proposed by psychologists and how it can help learners to get better results. This work reviews and presents a solution to enable SCORM LOM suporting both conceptes learning styles and pre-requisites. An architecture of such learning systems is then presented which adapts learning materials to learners based on learners' profile.

This paper is structured as follows. We present first the concept of learning style in section two and the one of learning object in section three. In section four we focus on SCORM on which we base our proposal presented in section five. Before concluding we present in section six the architecture of our system.

2 LEARNING STYLE

Many studies focus on the study of behavior of a human faced to a training session. In his book, the psychologist David A.Kolb (Kolb D., 1984) states that any person, who is in a learning situation to get a new concept, must go through a learning cycle consisting of four ordered phases. From a *concrete experience* phase of the target world, the person will be engaged in *reflective observation* phase on that experience, which will lead to an abstract conceptualization generating new hypotheses to be tested in a phase of *active experimentation*, feeding a new concrete experience that loops the cycle as shown in figure 1.

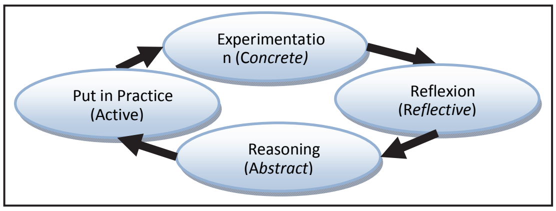

Figure 1: Kolb's Cycle.

Kolb (Kolb D., 1984) also noticed that each learner is characterized by the preferences he/she gives to one of these four phases of the learning cycle. On the basis of this learning cycle, Kolb positions the learner on two orthogonal axes: Concrete/Abstract and Active/Reflective (see Figure 1). From these two dimensions, Kolb propose four types of learning styles:

- The *Divergent* (Concrete/Reflective), is characterized by his capacity of imagination and his "emotional intelligence";
- The *Convergent* (Abstract/ Active), who likes to apply the ideas;
- The *Accommodator* (Concrete/Active), who prefers facts to theory and action to meditation;
- The *Assimilator* (Abstract/Reflective), who is interested in the concepts and theories.

Based on this theory, Professor Jean There (There J., 1998) established a standard of these learning styles called ISALEM-97 (L'Inventaire des Styles d'Apprentissage du Laboratoire d'Enseignement Multimédia).

The integration of learning styles in the training process seems to be very beneficial for learners, but some questions need to anwsered before apply it. First, how can learners be classified in their appropriate learning style? Secondly, how can we manage to present the same content, with the same objective, to different learners of different learning styles?

A first solution to these questions is to proceed as Kolb's experience propose: teach then first and then classify then after each assessment. In this case, the preparation of the content of the assessment must also take into account the classification in order to interpret the results of learners. Based on the results, a categorization of learners is performed which allows the teacher to prepare different approaches of presentation of the same content (same objective) to the various obtained classes. This approach is an ongoing and a long term work which will also situate the learner and eventually upgrade the learner to develop all his faculties of knowledge acquisition.

A second solution consists in passing a test to learners so that they can be classified as proposed by

ISALEM (Isalem-97). This test will allow the teacher to categorize these learners and then to prepare the presentations required for the subject to be taught. The major drawback of this approach is that the learner profile is fixed in advance, which does not give a chance for the learner to develop his abilities to acquire knowledge.

In his book, David Kolb (Kolb D., 1984) noted that the teacher has also preferences of learning style which influence him on preparing a learning content. Preaparing the same content in differente versions according to differente styles is thus a difficult task. It requires differente teacher with differente learning style preferences.

3 LEARNING OBJECT

The learning object is a current tendency that plays a very important role in the development of learning systems. Its goal is to produce usable and reusable digital courses in varieties of learning context situation (K.Verbert, 2004). Production of a course by an Author becomes just an assembling of existing learning objects and/or eventually a production of other learning objects that can be themselves reusable. To generalize this methodology of course design based on learning objects shared on the Web, standardization happens to be necessary. Many studies have been conducted in this context to describe precisely the features and services to ensure sharing and reuse of these objects (Forte E., & all, 1997) (Downes S., 2000) (Koper R., 2002).

Two proposals of standards for describing learning objects have emerged in recent years. The central objective concerns the indexing of learning objects for their reuse on different learning systems. The most important models and more standardized ones are:

- LOM (Learning Object Metadata), describes the object from an economic point of view (profitability, rationality and reuse) (LOM);
- SCORM (Sharable Content Object Reference Metadata), deals with object from a technical point of view (operating, control) (SCORM);
- IMS-LD (IMS Learning Design), deals with object from a pedagogical point of view (design, teaching tools, scenarios) (IMS);

Among these models, the most popular and largely used one is SCORM leading to a large variety of learning objects. This is what justifies our choice of SCORM as the underlying model of the solution that we propose. In the next part of this paper, SCORM is described and analyzed to see how it can be used to adapt learning resources to learner based mainly on his learning style and his acquired knowledge.

4 PRESENTATION OF SCORM

As described in ADL's work (ADL, 2009), SCORM allows the exploitation of learning objects on the Internet. Its main objective is to propose a formalism and a mechanism to describe and publish learning objects and control their uses.

SCORM proposes a learning object definition and exploitation process, composed of *Content aggregation, Metadata annotation and Content packing*.

4.1 Content Aggregation

The Content aggregation is based on the content Model (ADL, 2009) which describes the SCORM components used to build a learning experience from reusable learning resources. At the same time, the Content Model defines how these reusable learning resources are aggregated to compose units of instruction. A Content Model in SCORM consists in Assets, Sharable Content Object (SCO) and Content Aggregations.

4.1.1 Assets

An Asset (ADL, 2009) is an electronic representation of media, text, images, sounds, web pages, assessment objects, or other pieces of data that can be delivered to a web client. To be reused and reached within online repositories, Assets can be described with Asset Metadata.

4.1.2 Sharable Content Object (SCO)

A SCO in SCORM (ADL, 2009) is a collection of one or more Assets that include a specific launchable asset that uses the SCORM Run-Time Environment to communicate with Learning Management Systems (LMS). SCO represents the lowest level of granularity of learning resources that can be tracked by an LMS using the SCROM Run-Time Environment. SCO can be described with SCO Metadata.

4.1.3 Content Aggregations

A Content Aggregation (ADL, 2009) is an organized structure of content, which can be used to organize learning resources on a coherent unit of learning and to schedule learning resources, which are going to be presented to learners. Once defined, a Content Aggregation can be used and reused by LMSs, that's why they are described by metadata.

4.2 Metadata Annotation

Metadata in SCORM (ADL, 2009), based on the IEEE LTSC Learning Object Metadata (IEEE, 2001); describe different levels of the Content Model of learning units, such as Assets, SCO and Content Aggregation. This description ensures the research for these resources within and across systems to further facilitate sharing and reuse. As described in IMS Learning Resource Meta-data XML Binding Specification (IMS-LR), SCORM Metadata is composed by nine (9) categories of elements: general, lifecycle, Meta-metadata, Technical, Education, Rights, Relation and Annotation, where each category regroupeds elements referring to it.

4.3 Content Packing

A content packing in SCORM (ADL, 2009) defines the structure and the behaviour of a collection of learning resources. Its purpose is to provide a standardized way to exchange digital resources between different learning systems or tools. The structure of a content packing is as shown in figure2.

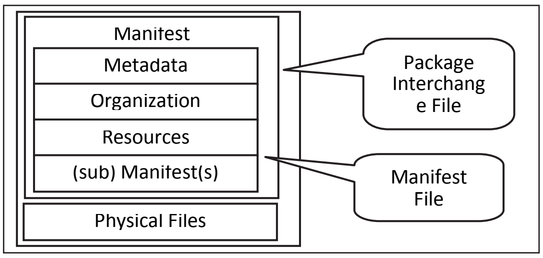

Figure 2: Typical SCORM Content Packing.

5 ADAPTING CONTENTS IN SCORM

After this overview and analysis, we present our proposal to enable SCORM to support contents based first, on learners' knowledge and second, on learner's learning style preferences.

5.1 Supporting Learner's Knowledge

In order to support learner's knowledge, learning system must maintain a knowledge profile for each learner, in which all acquired resources are hold. This information can be extracted from the "General" category of SCORM Metadata (ADL, 2009) which are: *General.Identifier, General.Title, General.Description and General.Keyword.*

Once maintained update, the learning system can use this knowledge profile to evaluate the learner's capabilities in terms of acquired Knowledge and pre-requisite knowledge.

5.1.1 Knowledge Already Acquired

Once a resource present in the schedule is acquired the adaptation process suppresses it from that schedule. This can be seen in the following scenario. Let us take for example two lessons with the organization as defined in figures 3 and 4 where S1, S2, S3, S4, S5, S6 are SCOs and A1, A2, A3, A4, A5 are Assets.

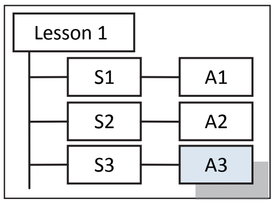

Figure 3: Learning Resource1.

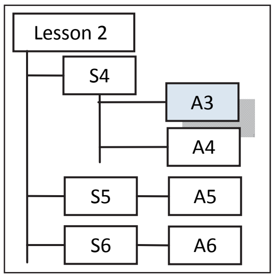

Figure 4: Learning Resource2.

Let's note that Asset A3 is both used by SCO S3 and SCO S4.

Let L1 and L2 be two learners. L1 wants to learn Lesson1 and then Lesson2, whereas L2 wants to learn only Lesson2.

As they are new in the learning system, their knowledge profile are empty.

Once learner L1 starts the learning process, the adapter schedules the Lesson1 learning resources as shown in figure 3. At the end of this learning process, the L1's knowledge profile becomes {A1, A2, A3}. As the resoure A3 is now acquired, the adapter schedules the Lesson2 learning resources as shown in figure 5, deleting resource A3 from Lesson2.

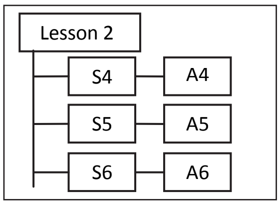

Figure 5: Organization of Learning Resource 2 adapted to learner L1.

At the end of the learning process of the Lesson2, L1's knowledge profile is {A1, A2, A3, A4, A5, A6}.

In the case of L2, the adapter schedules for the same lesson (Lesson2) the learning resources as shown in figure 4. At the end of Lesson2 learning process L2's knowledge profile is {A3, A4, A5, A6}.

This scenario confirms that it is possible to build a learner knowledge profile from the "General" category of SCORM.

5.1.2 Pre-requisite Knowledge

In the adaptation of learning resources to learner, the other most important pedagogical situation is to take into account, the pre-requisite resources when scheduling lessons. Let us illustrate this situation by the following example. Suppose that the knowledge within the learning resource S1 of Lesson1 is necessary to understand Lesson2, i.e. S1 is pre-requisite to Lesson2. Let us see now how the adapter process should schedule Lesson2 for learner L2. Referring to learner's knowledge profile and the pre-requisite resources of a specific lesson, the adapter can verify if learner is capable to learn this lesson or not. At this moment, the adapter will schedule Lesson2 to learner L2 as shown in figure 6.

At the end of the learning process L2's knowledge profile becomes {A1, A3, A4, A5, A6}.

To enable the scheduling of this type of situation, the authors must be given the possibility to specify pre-requisites resources during the description of the learning resources. Therefore, metadata must be supplied by some elements to enable the expression of such relationship. SCORM provide the "Relation" category in which the relationship between learning resources are described. Refering to (ADL, 2009), the element Relation.Kind defines all the kind of existing relationship between two learning resources. This element is bounded by a set of vocabulary defined by IEEE LOM (Dublin Core). This vocabulary is : IsParOf, HasPart, IsVersionOf, HasVersion, IsFormatOf, HasFormat, References, IsReferenceBy, IsBasedOn, Requires and IsRequiredBy.

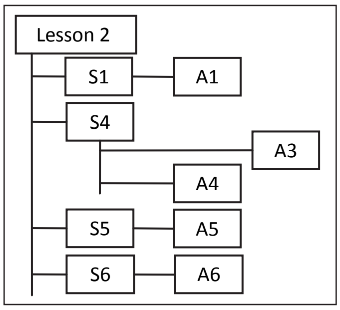

Figure 6: Organization of Learning Resource 2 adapted to learner L2.

Regarding to this description and this set of vocabulary, SCORM's Metadata doesn't support pre-requisite relationship. We thus propose to upgrade the existing set of vocabulary by the following new ones:

- *HasPrerequisite*: defines the pre-requisite resource specified on the element Relation.Resource, which is needed for the actual resource.
- *IsPrerequisiteBy*: defines the resource where the actual resource is pre-requisite.

This proposed solution enables SCORM to support the pre-requisite relationship between learning resources, by upgrading the IEEE LOM (Dublin Core) vocabulary used in Relation.Kind by HasPrerequisite and IsPrerequisiteBy. The learner's knowledge profile, can be of a great contribution in building an adapted scheduling of learning resources.

5.2 Supporting Learning Style

The second side of our contribution consists of the addition to SCORM of the very elements to let the adapter schedules learning resources based on leaning style. As it is defined, SCORM doesn't give much importance to pedagogy. Nevertheless, the "Educational" category holds some elements, which need to be further analyzed.

As mentioned earlier, David Kolb (Kolb D., 1984) proposed four types of learner : *Divergent, Convergent, Accommodator and* Assimilator.

Authors have thus to prepare four versions of the same lesson for each type of learner. See Figures 7, 8, 9 and 10 that show four versions of the same lesson but for different type of learner.

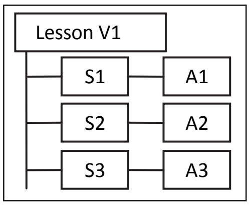

Figure 7: Lesson V1.

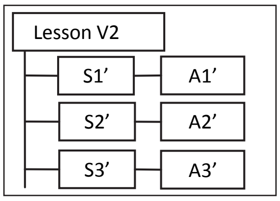

Figure 8: Lesson V2.

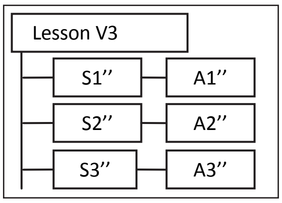

Figure 9: Lesson V3.

As we can see, the main difference between these lessons is the content of the learning resources which leads to the same learning objectives. Therefore, these four learning resources are different but are equivalent.

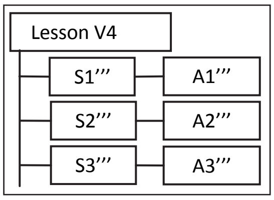

Figure 10: Lesson V4.

When applied to this example the following assumptions are valid:

1. Lesson V1, V2, V3 and V4 are equivalent;
2. Resources S1, S1', S1'', S1''' are equivalent;
3. Resources A1, A1', A1'', A1''' are equivalent;

To enable SCORM supporting learning styles it is necessary to:

1. Specify the learning style for each learning resource;
2. Specify the relationship between equivalent learning resources;
3. Keep track of the preference learning style for each learner;
4. Have a method to schedule the appropriate learning resources to learner.

5.2.1 Specifying Learning Style to Learning Resources

SCORM provides the category "Education" in which the element "Interactivity Type" indicates the flow of interactivity between learning resource and the learner. This element is bounded by a set of vocabulary defined by IEEE LOM (Dublin Core). This vocabulary is : Active, Expositive, Mixed and Undefined (ADL, 2009).

When comparing this vocabulary to the learning styles defined earlier, it can be observed that:

1. The *Assimilator* type of learner expects information to come only from the resource. This means that an *Expositive* resource is well suited.
2. The *Accommodator* type of learner prefers to participate to the learning process by being active. He surely prefers *Active* resource.
3. The *Convergent* type of learner prefers neither pure *Expositive* resource, nor pure Active resource; but prefers applying theoretical concepts. Therefore the suitable resource is the one which is at the same time *Expositive* and *Active* resource. That is the *Mixed* resource.
4. The *Divergent* type of learner prefers neither Expositive resource, nor *Active* resource. Therefore, his preference type of resource is not proposed yet by this vocabulary.

The proposed solution which enables SCORM to support all these learning styles, is to add a new vocabulary for the remaining learning style (Reflective type).

This proposed solution, gives authors the opportunity to specify the learning style of the learning resource on its metadata.

5.2.2 Relationship between Equivalent Resources

As mentioned earlier, specifying the learning style for learning resource doesn't mean that it is a new knowledge to teach but it is another way to communicate the knowledge of an existing learning resource. Therefore, they are two different but equivalent learning resources.

The proposed solution to enable SCORM to support this kind of relationship, is to upgrade the element Relation.Kind with a new vocabulary "IsEquivalentTo".

5.2.3 Keeping Track of Learner Learning Style

To give the opportunity to the adapter to provide the right resources to learners, the learning system must keep track of learning style for each learner. A learning style profile can be associated to each learner where it is hold all his preferences learning styles. This learning style profile must be kept updated.

5.2.4 Scheduling

When applying all these proposed modification on SCORM Content Metadata, the obtained result is an adapted scheduling of learning resources based on learner profiles (knowledge profile and learning style profile). As an example, the scheduling of the four versions of the same lesson described in figures 7, 8, 9 and 10, gives the result of figure 11. Where Type1, Type2, Type3 and Type4 are the four types of learning styles as defined by Kolb.

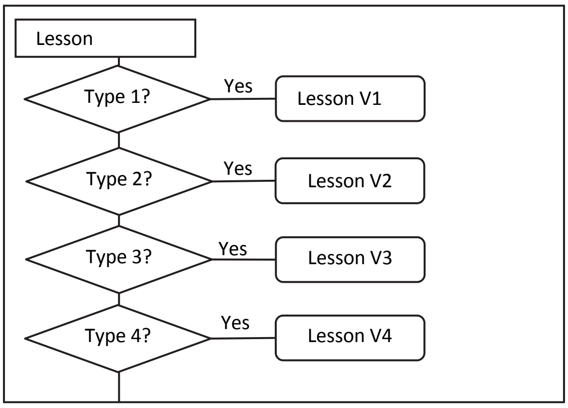

Figure 11: Organization of lesson after Scheduling.

This first scheduling gives to the learning system the ability to select the right resources depending on the learning style profile of the learner.

However, to adapt this first scheduling based on the learner profile (learning style and knowledge) and the pre-requisite resources of the selected lesson, the system must re-generate a new scheduling by adding or removing resources in the appropriate place of the learning style.

6 PROPOSED ARCHITECTURE

To support all the presented concepts of adaptation based on learner profile, the proposed architecture of the learning system is as shown in figure 12.

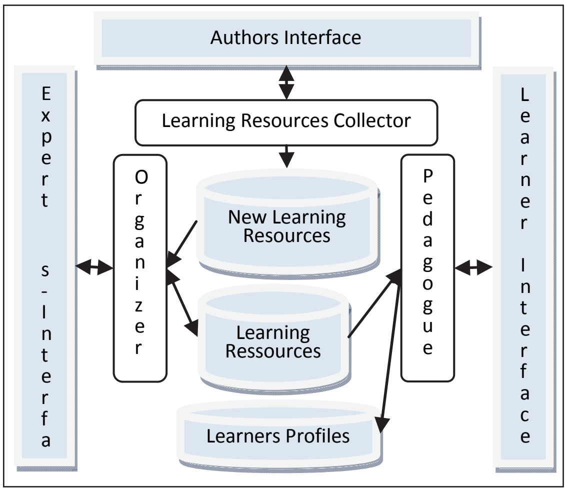

Figure 12: Architecture of a learning System.

This architecture supports the three types of users: Authors, Experts in pedagogy and learners. All these users are served by three modules and communicate with the learning system through interfaces. The roles of these modules are:

1. Learning resource collector: this module take care of all new learning resources uploaded by authors or those of other learning systems, it stock them into storage for further treatments by the Organiser;
2. Organizer: the new posted learning resources are analysed and verified if they contains pedagogical Metadata or no. If no, the human expert is solicited to add the appropriate Metadata. To be added to learning resources of the learning system, the new learning resources with pedagogical Metadata are related to the existing ones. This operation can't be done automatically but with the help of the human expert.
3. Pedagogue: this module satisfy the willing of the learner by proposing him course based on the learning resources available, the learner learning style preference and his background knowledge.

7 CONCLUSIONS

The main contribution of this paper is the introduction of the pedagogical side of the learning process into the learning systems. The pedagogical concepts introduced are the learning style and the acquired knowledge of the learner.

By this modification, learning systems become capable to adapt learning resources to the learner based on his preferred learning style and his acquired knowledge.

This proposed solution has upgraded SCORM metadata by introducing some new vocabularies by which pedagogical concepts were introduced.

To validate this proposed solution an architecture of learning system is presented. This system is under development.

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Benefits and Barriers of Older Adults' Digital Gameplay

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Keywords: Digital Games, Videogames, Older Adults, Seniors, Aging, Survey, Social, Socio-emotional.

Abstract: Gerontology researchers have demonstrated that cognitive and social factors are keys that may sometimes outweigh physical conditions in determining life satisfaction. Social interaction and cognitive challenge are consistently identified as key elements to enhance older adults' quality of life. Digital games can offer many potential benefits to older adults in a motivating and playful way, such as increased social interaction and maintenance of cognitive functioning. This paper describes some key results regarding socio-emotional and cognitive benefits as well as barriers reported from an early survey of 463 Canadian older adults who play digital games. The results demonstrate that a diverse group of older adults are actively playing digital games on a regular basis and that players report numerous socio-emotional and cognitive benefits and few difficulties. These results are promising and will be followed up with a variety of experimental studies.

1 INTRODUCTION

1.1 Background

The proportion of people age 60 and over is growing faster than any other age group and is predicted to grow to two billion by 2050 (Aalbers et al., 2011; WHO, 2002). Aging older adults face declining physical and cognitive capacities, shifts from career or family focus to different interests and activities, loss of long-term companions and social supports, changed living arrangements, and increasing likelihood of chronic and debilitating illness (Kaufman, 2013).

Successful aging - maintaining an independent, positive, independent, healthy, and meaningful quality of life - is a continual challenge for older adults, yet it is essential for older adults and their societies, which benefit both from older adults' continuing contributions and from reduced social and care costs (Kaufman, 2013).

Although a single clear definition has not been established for "successful aging" (Lee, Lan and Wen, 2011), gerontology researchers have demonstrated that cognitive and social factors are keys that may sometimes outweigh physical conditions in determining life satisfaction. Social interaction and support are consistently identified as key aspects of older adults' quality of life (Reichstadt, Sengupta, Depp et al., 2010). Declining social capacities are linked with declines in physical, cognitive and emotional functions (WHO, 2002) and their associated implications for disease, dependence, and poorer life quality. Digital games offer many potential benefits to older adults for improving social functions in a motivating and playful way. Using a positive psychology approach, Astell (2013) argues that games can contribute to older adults' happiness and life satisfaction through social interaction, cognitive exercise, and physical activity that motivates them to positively manage their lives. It is well known that games are engaging and promote flow experience (Csikszentmihalyi, 1990), support learning through graduated levels of practice, and offer opportunities for social interaction through group or online play (Kaufman and Sauvé, 2010).

As people get older, the social circle they developed through a lifetime will change and sometimes diminish. People who continue to maintain close friendship and find other ways to interact socially have reduced risk of mental health issues such as depression and live longer than those who become isolated. The psychological effects of social support in older adults have received a substantial amount of attention during the last two decades. A consensus view has been reached that the more opportunities an individual has to interact with other people, the more social support will be available, which, in turn, will have a beneficial effect on general wellbeing. For example, Glass, et al.'s study (2006) found that higher levels of social support were associated with lower levels of depression.

A study conducted by Forsman et al. (2012) showed the effectiveness and subjective importance of social activities for the maintenance of mental health and well-being among older adults. Individuals derive positive outcomes and resources from personal relationships and interpersonal contact.

Maintaining older adults' vitality, independence and quality of life well into old age helps both older adults themselves and their societies. The potential for technology to support older adults to live well and experience the things that make life worth living has received much less attention than the physical, mental and social challenges they face. However, evidence suggests that technology can provide people with meaningful and engaging activities that are stimulating, enjoyable and fun (Sixsmith et al., 2007). In particular, technology-based games promise many benefits to older adults, but research evidence is sparse about whether and how these can be realized. The evidence and guidelines for practice that will result are expected to benefit not only individual older adults, but also their families, communities and societies-at-large.

1.2 Purpose of the Study

The purpose of this survey was to explore the opinions and experiences of older adults (55 years and older) who play non-digital and digital games. It explored issues such as which games they play, with whom they are playing, how frequently they play, the reasons they play, and their perceived benefits and barriers. There also were questions about their ratings of social, emotional and cognitive changes through game play. Older adults' backgrounds and patterns of use were examined and compared with their opinions and experiences to search for relationships.

The survey will help to inform future studies that may investigate the use of digital games as a way to stimulate cognitive functioning and enhance psychosocial aspects that may help individuals to age more successfully.

1.3 Research Questions

1. What are the patterns of digital gameplay reported by older adults?
2. What are the socio-emotional and cognitive benefits of digital gameplay reported by older adults?
3. What are the difficulties in digital gameplay reported by older adults?

2 LITERATURE REVIEW

2.1 Social Interaction and Successful Aging

It is well established that social engagement is seen as an important component of successful aging (Ristau, 2011; Von Faber et al, 2001). Prior epidemiological, cross-sectional and longitudinal research has shown that older adults with high engagement in social interaction report more positive wellbeing. Glei et al. (2005) examined how changes in cognition over time are related to social participation and the extent of social networks. Data draw from this population-based, longitudinal study revealed that respondents who engaged in one or two social activities failed 13% fewer cognitive tasks than those with no social activities, and those who participated in three or more activities failed 33% fewer cognitive tasks. Glei et al. (2005) also indicated that social interaction outside the family may have a bigger impact on cognitive function than social contacts with family. In addition, social engagement provides opportunities for older adults to deal with stress and receive social support and connect with friends. Eisenberger et al.'s (2007) study with 30 participants yielded supportive evidence that individuals with regular social interaction during 10 days showed diminished neuroendocrine stress responses and distress of social separation.

2.2 Cognitive Functioning and Successful Aging

While physical and cognitive decline is generally thought to be a natural trend of aging, emerging evidence from social and cognitive neuroscience suggest that appropriate training or therapeutic techniques could not only slow, but also actually reverse this trend (Green & Bavelier, 2006). For example, Ball et al. (2002) examined the effectiveness of three cognitive training interventions on the mental abilities and daily functioning in independent-living older adults. In comparison to baseline, participants in experiment groups exhibited immediately improvement in processing speed, reasoning and verbal episodic memory after 19-month intervention period, which were maintained at the two-year follow-up. Empirical evidence suggests that cognitive decline that is part of the natural aging process could be slowed or reversed by getting the elderly involved as active users of video games. Basak, Boot, Voss, and Kramer (2008) reported the use of a real-time strategy video game for the enhancement of executive control processes of older adults. They found that after a period of 23.5 hours game playing participants in the experiment group improved significantly more than participants in control group in executive control functions, such as task switching, working memory, visual short-term memory, and improving. Maillot, Perrot and Hartley (2011) assessed the potential of physically simulated sport games that could have cognitive benefits for older adults. The experimental group participated in a total of 24 hours of game training. In comparison to the control group, the experimental group underwent significant changes in executive control and processing speed.

Although these studies suggest that video games could be a powerful tool in slowing or reversing the age-related declines in perceptual, motor, and cognitive skills among older adults, some contradictory findings have been reported.

2.3 Digital Games and Older Adults

Older adults use many leisure activities offered by Information and Communications Technologies (ICTs), one of which is digital games (e.g. video, computer, and online games). DeSchutter (2011) investigated the use of digital games among 124 older gamers. He found that 16.1% are heavy gamers who play digital games more than 2.5 hours a day; 29.5% are moderate gamers who play 1 to 2.5 hours a day; 44.4% are light gamers whose time of digital game playing is less than one hour a day. The mean playing time is 1.45 hour a day (SD=1.14). In 2005, 18% of gamers (about 1.7 million) in UK were aged between 51 and 65 (Pratchett et al., 2005). Both heavy and light gamers are significant in this age group. In 2011, 29% game players in America were aged 50 and over (Entertainment Software Association, 2013).

Digital games hold a significant promise for enhancing the lives of older adults (Ijsselsteijn et al., 2007). Games that require progressively more accurate and more challenging judgments at higher speed, and the suppression of irrelevant information can drive positive neurological changes in the brain systems that support these behaviors. Also, in most digital games, hand-eye coordination, sustained attention to the task, as well as the ability to quickly locate a proper area of the screen is required. As the players practice and become proficient at these tasks, it is expected that their visual-spatial skills will be developed. What's more, digital game playing is increasingly becoming a means for social interaction (Mahmud et al., 2010). It has been hypothesized that digital game holds great promise for enhancing the quality of life in older people by improving their subjective well-being, enhancing their social connectedness, and offering an enjoyable way of spending time (Whitcomb, 1990).

Older adults have recently begun to experience the benefits of online communities as a medium for fun social interactions. In two studies of online communities, the majority of posts were part of online social games, including cognitive, associative, and creative games (Nimrod, 2010, 2011). He concluded that because online communities offer both leisure activity and an expanded social network, participation in these settings may contribute to the well-being of older adults. Recent research suggests that training in technology use can enhance older adults' cognitive functions as well as facilitate their social interaction and support. Astell (2013) suggests that games and social/interaction technologies offer both cognitive stimulation and social connection, particularly for older adults with dementia. Many older adults are already active technology users and should be able to readily learn and use digital games. (Pew Internet and American Life Project, 2011). *ELDERGAMES* (Gamberini et al, 2006) and *HERMES* (Buiza et al, 2009) show promise for improving cognitive function, although we are not aware of controlled studies measuring their impact. Regarding older adults' social interactions, Whitcomb (1990) identified several early studies in which older adults had positive social experiences when playing computer games. Participants in the *ELDERGAMES* project identified social interaction, defined as the "opportunity to create and maintain new relationships" as that game's biggest benefit. Researchers agree that much additional work is needed to establish whether and in what forms digital games can best and most efficiently benefit older adults. This issue has been addressed by

Ijsselsteijn et al. (2007), who identified four potential areas for games to contribute to improving the quality of life for older people: (1) relaxation and entertainment, (2) socializing, (3) sharpening the mind, and (4) more natural ways of interacting. The socializing and cognitive areas represent two of the three foci of this study. Very few rigorous experiments have been conducted, and our current knowledge of older adults' needs suggests that today's commercial games pose usability challenges for many older adults (Buiza et al, 2009; De Schutter, 2011). Yet new platforms such as the iPad and mobile devices offer great opportunities for ease of use (e.g., ipadnewsupdates.com)

Conclusions are difficult to draw from current empirical studies because inconsistency is related to many factors, including the demographic information of participants (e.g., age, education level, etc), the ratio of male vs. female, research design, the wide variety of outcome measures used, control variables in multivariable models, appropriateness of the selected video games, training interventions, etc. For example, Laver et al.'s (2011) study recruited 21 participants, 86% of whom were female. The large proportion of female participants may lead to the preference of conventional therapy programs over Wii Fit programs because there are more male gamers than female gamers (Entertainment Software Association, 2011; Entertainment Software Association, 2012). One tangible way to assess the effects of video games on the motor and cognitive functions in older adults is through the incorporation of outcome measures across available quantitative studies and taking into account the methodological characteristics and various outcome measures by conducting several moderate analyses (Borenstein et al., 2009).

3 RESEARCH METHOD

3.1 Participants

The population that was targeted comprised older adults, age 55 or more, who play digital games. We included both those who have and those who haven't retired since many people work part- time, or do voluntary jobs after retirement. Also a non-retired older adult group added an interesting comparative group. This involved 891 participants recruited from assisted living and community centres, shopping malls, and other public venues as needed. 463 of these responded to the digital gameplay section of the survey and are the focus of this paper.

3.2 Instrument

This study used a print-based, mainly closed-ended, questionnaire that consisted of questions that asked older adult gamers about their background characteristics, demographics, patterns of use, opinions, and experiences. A small number of open-ended questions were asked to gain a deeper understanding of some issues. The survey asked about background information, digital game playing patterns and experiences, and opinions regarding social, psychological, cognitive and educational aspects. Respondents required 15-20 minutes to complete the survey and received a $5 coffee card for their participation.

3.3 Recruitment and Data Collection

Recruitment occurred through four methods. Firstly, a number of older adults' independent/assisted living centres were targeted. Secondly, centre directors were contacted to assist in recruitment in local community centres and older adult centres. Thirdly, directors of local shopping malls were approached for permission. Finally, directors of independent and assisted living facilities were contacted. Each potential participating organization was sent a Recruitment letter and if they agreed, they replied in writing by email or letter. As recompense for the time involved, participants were offered a gift certificate of $5 for their participation, and offered entry into a draw for three chances to win $100 upon completion. If they agreed, respondents were given a separate postcard to provide their contact information in order to maintain their anonymity. Respondents also were asked whether they would be willing to be contacted later for a short interview. Six months after the draw was completed and the prizes awarded, all cards were shredded.

3.4 Data Analysis

The data were analyzed using the SPSS software (version 19). The descriptive statistics are reported below.

4 FINDINGS

A total of 463 completed questionnaires were received from older adults who play digital games. Selected findings from the analysis of their responses are reported below.

4.1 Participant Backgrounds (N=463)

1. **Sex:** Male, 39%; Female, 63%
2. **Age:** 55-64, 37%; 65-74, 36%; 75+, 25%
3. **Where do you live?:** Home, 83%; Assisted living, 8%; Nursing home, 0%; Other, 9%
4. **Are you retired? Yes, 80%; No, 20%**

Almost two-thirds (63%) of respondents were females; respondents ranged in age from 55 to 89 years and were fairly balanced across the three age categories. Most (83%) lived at home and 80% were retired.

4.2 Participant Gameplay Patterns (N=463)

1. **How many years have you been playing digital games?**
   Less than 1 year. 20%
   1-4 years, 30%
   5-10+ years, 50%
2. **Have you played digital games in the past month?**
   Yes, 84%
   No, 16%
3. **During the past month, during how many days per week on average have you played digital games?**
   0 days, 12%
   1-4 days, 54%
   5-7 days, 34%
4. **During the past month, when you played digital games, how many hours per day on average did you play?**
   1 hour or less, 0%
   2-5 hours, 92%
   6-8+ hours, 8%
5. **Have you played social games online with other players? (e.g., bridge, chess, scrabble, Facebook games)**
   Yes, 27%
   No, 73%

About half (50%) have played for 5 years or more. Most (88%) reported that they had played at least one day or more per week on average. It is interesting to note that almost all respondents (88%) played digital games every day or every other day and almost all (92%) played between 2-5 hours per day when they did play. More than one-quarter (27%) had played social games with other players.

4.3 Reported Social Benefits (N=463)

Table 1 lists the greatest benefits of playing digital games reported by participants.

Table 1: Greatest benefits of playing digital games.

Benefit	% Selecting[1]
Mental exercise	83
Social interaction	26
Enjoyment, fun	71
Escape from daily life	26
Other	7

[1]Respondents could select more than one benefit.

Most (83%) of respondents reported that 'mental exercise' was the greatest benefit of playing digital games. The next greatest benefit was 'enjoyment/fun' (71%). Social interaction was reported as a benefit by more than a quarter (26%) of respondents.

Table 2 below shows the self-reported socio-emotional benefits of playing digital games (n=463).

Table 2: Socio-emotional benefits of digital games.

Benefit	% Reporting an Increase[2]
Developing new friendships	26
Connecting with current friends	27
Connecting with family	33
Connecting with various age groups	28
Developing confidence	42
Dealing with loneliness	35
Dealing with depression	24

[2]Almost no one reported a decrease. Some reported no change.

From about a quarter (24%) to almost a half (42%) of respondents reported socio-emotional benefits. The greatest benefits reported were developing self-confidence, dealing with loneliness, and connecting with family.

The results in Table 3 show that the great majority (between 58% and 72%) of respondents reported an increase in cognitive skills as a result of playing digital games.

A further finding (not in a table) was that 61% reported an increase in computer skills and 54% reported an increase in internet skills as a result of playing digital games.

'Too complicated' was the greatest difficulty reported, but by only about one fifth (21%) of respondents.

Table 3: Cognitive benefits of digital games.

Benefit	% Reporting an Increase[3]
Focussing attention	72
Memory	69
Reasoning	58
Problem solving	65
Speed in reacting/ responding	66

[3]Almost no one reported a decrease. Some reported no change.

Table 4: Difficulties in playing digital games.

Difficulty	% Selecting[4]
Difficult to see/ hear	0
Too complicated	21
Privacy	5
Difficult to use controller	10
Limited/ no access to technology	10
Other	12

[4]Respondents could select more than one difficulty.

5 CONCLUSIONS

These results demonstrate that a large and diverse group of older adults are actively playing digital games on a regular basis. Many players reported a number of socio-emotional benefits, and almost three-quarters reported some type of cognitive benefit. These results are encouraging for using digital games to enhance the aging process of older adults. However, it should be emphasized that these results are preliminary. The next step will involve further data analysis to investigate whether there are particular groups that benefit more from playing digital games, e.g., older adults, expert players, active players. Then a series of experiments are being planned to directly address the socio-emotional and cognitive benefits of digital games for older adults. These experiments will include research to clarify whether gameplay is effective or not based on objective evaluation criteria.

Overall, this study provides a positive starting point for determining whether digital games may improve the quality of life in older adults. Improving lives through play is an appealing idea, and play itself also has been shown to lead to powerful learning (Kaufman & Sauve, 2010). The potential for digital games to provide benefits to older adults, even when they may be homebound or isolated, is exciting. It may be that in our technologically focused culture, digital games are a way to assist older adults in feeling more connected with the world, while providing a enjoyment as well as a social and stimulating environment. Play is not only for the young, but can be used throughout the life cycle to connect and bring joy at any stage.

ACKNOWLEDGEMENTS

We wish to thank the Social Sciences and Humanities Research Council of Canada (SSHRC) for supporting this project financially through a four-year Insight grant.

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Through the Lens of Third Space Theory
Possibilities for Research Methodologies in Educational Technologies

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Keywords: Educational Technologies, Third Space Theory, Research Methodology.

Abstract: Recently, there has been a call to reconceptualise the ways in which the field of education technology is researched and theorised (Graham, 2011). This article responds to this call, through discussing the potential of utilising Third Space theory as a research methodology in relation to the use, adoption and resistance to educational technologies. We begin by discussing the under-theorised and technocentric narrative that is dominant in current research approaches. We then outline the premise of Third Space theory and signal some of the possibilities this paradigm may offer to study the complexity of educational technology use in schools, professional learning and university contexts. The article then discusses findings from two different research projects which utilised Third Space to examine the ways in which beginning teachers and pre-service teachers navigated first and second space binaries and took up third spaces in order to destabilise and construct alternative knowledges and practices in relation to educational technology.

1 INTRODUCTION

The real voyage of discovery consists not in seeing new landscapes, but in having new eyes (Proust, cited in Canfield et al., 2002, p. 153).

With whose eyes were my eyes crafted? (Castor, 1991, cited in Davies, 1994, p. 18)

The methodology which a researcher employs has a number of implications for the scope of the study and the contribution of the research to the field. The methodology choice also orientates the values and beliefs that underpin the research and provides a lens to guide the researcher (Guba, 1990). For instance, the choice of methodology influences the lens in which the research is positioned and structured, the practices of the researcher (e.g. line of questioning) (Kuhn 1996) and the methods employed to conduct the research (Mertens, 2010). It can also determine the practicalities of the research – the who, why, what, where, when and how – and this will impact upon what is featured, highlighted, silenced and marginalised in the study. In this paper we argue that traditionally the methodology employed in educational technology research has led to technocentric and simplistic approaches to research; and the field has "learnt to see" educational technologies in particular ways, which we would argue can be limiting. In this paper we propose a move beyond a commitment to 'one truth, one method and one knowledge' and instead discuss ways to include more diverse ways of knowing, lenses for seeing and crafting research in this field (Grosz, 1994). To this end, we consider the potential that the theoretical paradigm Third Space can offer as a research methodology in the study of educational technology.

2 EDUCATIONAL TECHNOLOGIES RESEARCH

A key premise of Third Space theory is that everything is called into question (Hulme et al., 2009) and this includes taking up the challenge of integrating competing knowledge and challenging the binaristic thinking that has populated the research of educational technologies. The call to do so was highlighted in a recent paper in Computers & Education, Charles Graham (2011) by way of leading into his focused discussion of the TPACK framework. He argued that one of the reasons for its popularity is because educational technology has been under theorised. He then went on to suggest a number of reasons for this apparent void in theory including the rapid pace of technological change, a tendency in the past to ask the wrong questions, weaknesses with methodological designs, and lastly, more priority being given to practical issues rather than on theory building. In this paper we wish to highlight some of the issues around methodological designs that have typically underpinned educational technology research as a way of advocating for alternate ways to do so.

In the past methodological designs in educational technology research have followed a similar pattern. At their heart has often been a world-view that implicitly assumes that technology is good, that for example, it is aligned with the future, and drives desired changes in education. One only has to peruse school education policy documents to find plenty of examples of this way of thinking, and where a technological road map that schools, school leaders and teachers should follow is provided, and where there is little capacity to consider detours or alternate routes. Underpinning this world-view is a techno-centric discourse, which places technology at the centre of the research if not the determining factor in it. This techno-centric discourse is the dominant discourse around educational technology research (Harris, 2005). It is important to note that dominant discourses, tend to subsume other less dominant ones (Gee, 1998), and as such, this may help explain why our educational technology field is under theorised.

In order to build a case for the research, or a justification for it, a problem in current practice is identified and a particular technological application is then later pitched as the solution (Bigum, 1998). Usually this case is made in overly enthusiastic terms, in what Selwyn (2002) refers to as the "technological evangelism" (p. 8) typifying this discourse. When building this case for the research, arguments usually take one or two forms. One way is to compare the 'new' to the 'old', with arguments around the superiority of the new, resulting in the conclusion, that the new technology must replace the old. Usually, there is little, if any consideration that both 'the old' and 'the new' can indeed co-exist. This has been the case historically, for example, in the 1980's revising writing was seen as time consuming (the old) and word processors (the new) were seen as making revising easier. In the 1990's conventional face-to-face participation in class discussion was seen as enfranchising those who think quickly on their feet. Electronic discussion was then juxtaposed, as enabling leaners to discuss when and where they want to.

A second way that the case is made is that particular affordances within a 'new' technology are identified as solutions to the problem (Zhao & Rop 2001). This was the case in the 2000's, were web 2.0 technologies, such as blogs and wikis were readily positioned in research as enabling greater collaboration, interaction and knowledge building. The specific research questions then set out to prove that 'the new' or the 'affordances within the new' did in facto solve the problem. So for example in the late 1990's questions in hypertext research set out to examine how the new text structures afforded by this technology enabled the realisation of post-modern views of text – which were desired (Lankshear et al., 2000). Methods of data collection, particularly in the early years of educational technology research used anecdotal reports, or descriptions of practice. Findings were typically generalised, so that the particularities in the technologies being examined were overlooked, as well as the context of use. As a result, it was often assumed that all schools, all students, all teachers were the same and that predetermined technologically-enabled outcomes would be realised (Orlando, 2009).

Of concern to us is that without robust theoretical frameworks to both guide and shape research, that encourage us to assume diverse worldviews - with different questions in mind - techno-centric views will continue to underpin the landscape. Technocentric views only offer one lens with which to view our research, one that is based on binaries of good/bad, old/new, which limit alternate ways of conceptualising research. One theory which encourages this practice of looking at the complexity and multiplicity in educational technology is Third Space theory.

3 POTENTIAL OF THIRD SPACE THEORY

Third Space theory is essentially used to explore and understand the spaces 'in between' two or more discourses, conceptualizations or binaries (Bhabha, 1994). Soja (1996) explains this through a triad where Firstspace refers to the material spaces whereas Secondspace encompasses mental spaces (Danaher et al., 2003). Thirdspace, then becomes a space where "everything comes together" (Soja, 1996, p. 56, original emphasis) by bringing together Firstspace and Secondspace, but also by extending beyond these spaces to intermesh the binaries that characterise the spaces. Third Space theory is used as a methodology in a variety of disciplines and for different purposes. For example, it has been used to illustrate issues from colonization (Bhabha, 1994) and religion (Khan, 2000), to language and literacy

(Gutiérrez et al., 1997).

Bhabha (1994) illustrated his conceptualization of Third Space through the discussion of cultural identity and colonization. Specifically, he explored the ways in which people negotiate being in-between their own traditional culture and the newly imposed culture; in other words being in-between first and second spaces. Bhabha (1994) argues that through a continual negotiation, reinterpretation and creation of identities, a hybrid or a third space which challenges both cultures is created. In illustrating the work of Bhabha - and drawing heavily from his explanation of Third Space - we are mindful that Bhabha's notion of Third Space is associated with the critique of colonization which does not directly relate to our research (Hulme, Cracknell & Owens, 2009). However, aspects and foundations of his work are useful in our research around the utilisation of technologies in educational spaces.

Within educational contexts, Moje, et al. (2004) used Third Space theory to examine the in-between everyday literacies (home, community, peer group) with the literacies used within a schooling context. In their influential paper, they summarized the three main ways that theorists have conceptualised Third Space which includes: as a bridge; navigational space; and a transformative space of cultural, social, and epistemological change. To explain in more detail, the first way perceives third space as a bridge which according to Moje et al. (2004) helps learners see connections and contradictions and enables them to bridge competing and contradictory understanding. This concept was illustrated in Moje's et al. (2004) research into how students bridged inside and outside schooling literacies in the classroom and in doing so, created a space for typically marginalised voices or stories within their learning. When perceived as a navigational space, participants can cross over or draw upon different binaries, discourses or discursive boundaries. The other way that Third Space can be perceived is a transformative space, in which students' linguistic and cultural forms, goals, or ways of relating, transform the official space of the school, teacher, or classroom - enabling participants to become more central to their learning and gain access to alterative knowledges (Gutiérrez et al., 1999). This was evident in Elsden-Clifton's (2006) research into the visual arts created by migrant students, which found that students used their art to navigate between cultures and in doing so, negotiated being connected to, and 'in-between', different countries, cultures and spaces.

We have currently been involved in two recent research projects which have used a Third Space theory which we now turn to explain.

3.1 Example 1: Beginning Teachers, Professional Learning and Educational Technologies

The first research project used Third Space theory in a small-scale exploratory study that reported on ways in which 26 beginning teachers and an instructor, along with 3 online coaches and 2 moderators interacted in one Blackboard (Bb) Collaborate session during a professional learning program. In the design and implementation of this research study, we were mindful of the dominant approaches that have been used in researching the introduction of new technologies. First, we wanted to move away from simplistic notions associated with the introduction of technology in learning (e.g. Bb Collaborate is a better method of instruction, when compared to older ways of instruction, or has particular affordances which should be used to remedy shortcomings or problems in instruction). Instead, we wanted our research to focus more on the complexities involved and acknowledge more critical views of technology introduction and use. In our quest we turned to the methodology of Third Space as it opens up difference spaces, allows for different presumptions around technology use by our research participants and ways of knowing our research site.

For this research study we associated conventional notions of face-to-face instruction with first space and the computer-mediated communication technologies, with second space. We identified three instances in an online interaction on Bb Collaborate between beginning teachers and instructors where the participants took up third spaces. We found that that beginning teachers were able to navigate, bridge and transform spaces and take up hybrid or third spaces. In particular, they disrupted the expert/novice binary by challenging the "teacher" and asking for and providing peer feedback rather than looking always to the expert. When in this third space, beginning teachers were able to take control of this space, shaping it to suit their own learning needs and destabilising the traditional roles of teacher/student. Thus, they were able to disrupt the traditions of first and second spaces and ultimately challenge who controls the interactions and the space. This research demonstrated some of the ways in which the theory may provide a way of recognizing the dynamic and maybe contradictorily spaces that educational technologies may take us.

3.2 Example 2: Pre-Service Teachers using Educational Technology on Placement

The second project investigated pre-service teachers' familiarity, confidence and perceived knowledge and skills of ICT implementation in the classroom during practicum. This research involved up to 70 pre-service teachers along with the School Principal and Teacher Mentors at their practicum school site. We were drawn to the Third Space construct as it enabled us to make visible the connections, and movement between binaries of pre-service teachers while on practicum in school (Bhabha, 1992). It provided a framework to acknowledge the tensions and dilemmas of pre-service teachers on placement as they struggled "to negotiate unfamiliar terrain" moving from their education application of technology (first space) and their personal knowledge of ICT use (second space).

Pre-service teachers while on placement inhabit a third space; they neither "belong" to the school, nor are they "at" university, thus, they are in-between these two spaces or in a third space. Through its emphasis on "between" we were able to research some of the struggles that pre-service teachers encountered as they interweaved the binaries of university/school, public/private, known/unknown, known/acquired and learner/teacher. It also provided a lens in which to examine the difficulties faced by pre-service teachers as they attempted to cross the boundaries of university based learning to learning to use technology in schools. The potential of third space for this research is that it did not see this dilemma or struggle as problematic or negative. Instead, Third Space methodology enabled us to draw attention to complexity around how pre-service teachers use technology while on placement and draw out the multiple possibilities and constraints of pre-service teachers' experiences of ICT while learning to teach.

4 FINDINGS

This paper has attempted to respond to the call for a continued conversation around the theoretical lens used to research educational technology. We believe that Third space has the potential to contribute to the field of educational technologies in three key ways, this includes:

- Provide a framework for destabilising and moving beyond the past patterns and stories of research in education technologies that encourage us to ask different research questions which consider alternate conceptualizations of uptake and use, rather than relying on binaries of good/bad, new/old, updated/outmoded, and valued/undervalued that have often characterized research
- Provide a research methodology that enable us to explore complexities in teacher use of technology
- Helping us to wrestle with the questions and complexities of education technology use in diverse contexts.

By proposing the use of Third Space theory within educational technology research, it is our hope that we contribute to an on-going conversation about the ways in which we research educational technologies. To this end, we feel it gives us possibilities to examine the complexities in education technology use and enables us to ask alternative research questions, that focus on the how and why of technologies within particular contexts rather than the what of technologies themselves. In doing so, it would also open up diverse research sites and take up potential opportunities to research more complex conceptualizations and move away from an overreliance on technocentric and binaristic conceptions of research.

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Perceived Quality of Service and Content-based Bandwidth Management in e/m-Learning Smart Environments for the Cultural Heritage

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Keywords: Perceived Quality of Service, Smart Applications, Cultural Heritage, e/m-Learning, Quality of Service Management.

Abstract: Smart Applications for the Cultural Heritage are playing an increasingly fundamental role in several fields, ranging from tourism to home entertainment. E/m-Learning systems are also involved, since advanced contents from the Cultural Heritage can be used in History of Art lessons. For instance, teachers can decide to make students enjoy HQ images or videos of masterpieces, accessed from the Internet. In this context, several problems must be considered, among which an appropriate fruition of such data. In this paper, two specific issues are taken into account: firstly, the so called Perceived Quality of Service (PQoS) in case of visual information; secondly, the case is discussed of high-bandwidth demanding contents accessed in real-time, such as HQ streaming videos. An early architecture is finally proposed for the dynamic management of bandwidth release on the basis of content size and duration.

1 INTRODUCTION

The increasing availability of rich multimedia contents from the Internet is playing an important role in several services. Consider for instance smart applications for the Cultural Heritage, currently used in many fields, such as tourism and home entertainment. Such applications are full of interesting contents, that can be used in e/m-Learning activities, for instance in the field of History of Art. This case is here discussed, and the following scenario considered: a teacher and his or her students use an e/m-Learning system, where contents from the Cultural Heritage are adopted, such as HQ images or videos available on the Internet. Teachers choose which visual information must be accessed; students follow lessons from home or outside, using: (1) heterogeneous devices, such as desktops, laptops, tablets and smartphones, and (2) different network access connections, such as a WiFi from a 100 Mbps wired, a 20 Mbps DSL or GPRS (2 Mbps, used in several smartphones or tablets if no WiFi is at disposal).

The learning goal is to enjoy rich and detailed contents properly, for instance in History of Art lessons. In this case, HQ images or videos need to be accurately displayed. The problem is particularly important of visual quality, which depends on several factors, such as screen resolution and network access speed, especially if high-bandwidth demanding contents are accessed in real-time.

Contents are meant to be shown to a class, but each student accesses the system using his or her device and network access technology, which can both vary over time depending on where and how students log on to the system. In consequence, the possibility to access the requested visual information properly or not must be checked for each individual, according to distinct situations and learning tasks.

This paper focuses on two specific and related aspects concerning quality of advanced visual contents from the Cultural Heritage and their use in smart education environments (images and videos). First, the concept is investigated of “Perceived Quality of Service” (PQoS) in visual environments, and a representation is proposed of the steps between reality representation and perception. The considerations made refer to every kind of visual information, but are particularly important in case of contents from the Cultural Heritage. The second aspect faced refers to lessons involving high bandwidth-demanding contents, such as HD streaming virtual visits to museums, where the bottleneck is data dimension with respect to network access speed. An early architecture is consequently proposed for the dynamic management of bandwidth release on the basis of content size and duration.

As an introduction, some considerations are made about PQoS, quality of transmission and display, and a representation proposed of the main steps among the object represented and its final perception. As for PQoS, the term “Quality of Service” (QoS) (Bai, B., 2010, Ganesh Babu, T.V.J., 2001, Montazeri, S., 2008) is rapidly evolving into the concept of PQoS. In Smart Environments, PQoS (Suffer, D., 2009, Vankeirsbilck, B., 2013, Zhengyong, F., 2013) depends strongly on the user, senses involved, kind of application, architectures, advanced interfaces and technologies applied, concerning both devices and kind of network access. This is the link between the first and second aspect discussed: quality of perception in visual smart environments strongly depends on technical factors. Quality of image and video transmission, in particular, are related to both bandwidth required and access technologies, and the following considerations can be made. First, Smart Environments are increasingly being enjoyed through mobile devices and wireless networks; second, contents from the Cultural Heritage are growing richer and increasingly bandwidth-demanding. The network and its performance, thus, are fundamental. The same applies to device quality, such as screen size and resolution.

Fig. 1 represents the layers among every kind of visual object and its final perception. In more detail, the factors defining quality of service and its perception in smart visual applications, can be classified as: (i) actual contents and their representation; (ii) smart application architecture; (iii) smart application interface; (iv) network architecture; (v) user’s network access technology; (vi) user’s device; (vii) user’s personal perception. The schema in Fig. 1 does not mean to be exhaustive: as a matter of fact, each layer depicts in a symbolic manner a set of contents, methodologies and technologies, each strongly dependent on the kind of application. For instance, in advanced services for the Cultural Heritage, the layer between the object and the smart application architecture comprehends (at least) advanced digital video instrumentation and exposure techniques, data compression algorithms, data storing methods, etc.

In this simplified and general representation, an object (meant as a content of any kind and complexity), is acquired through specialized media.

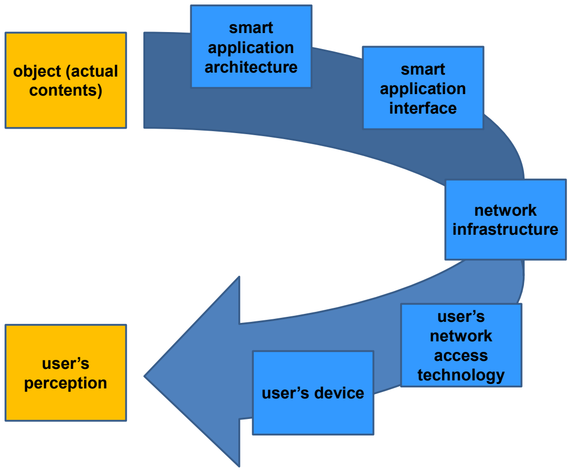

Figure 1: Main layers between contents and the user’s perception.

Data are transmitted through a network infrastructure (e.g. a 100 Mbps fixed network), accessed by the user on the basis of his or her access technology (e.g. a WiFi on a 20 Mbps DSL) and through his or her device (e.g. a notebook or a tablet).

All the above factors contribute to the final perception. In particular, an appropriate transmission and reception of images and videos (such as HD streaming) strongly contribute to the user’s overall perception. QoS management, thus, here meant as an appropriate bandwidth distribution, becomes a focal issue in PQoS and must be properly handled with. This is particularly important when groupwork activities are scheduled, such as lessons involving the simultaneous vision of high bandwidth-demanding contents. As a matter of fact, the lesson is address to a group, but, since each student is free to access information using his or her device and network access technology, supervision concerns individuals.

The paper is organized as follows: Section 2 extends the representation in Fig. 1 and proposes a simple definition of the factors of PQoS. Section 3 discusses an early architecture for enhancing dynamic QoS management in case of high bandwidth-demanding visual contents. In particular, the dynamic service allocation policies in (Toppan, A., 2012, Won-Kyu Hong, D., 2003) are revised and adapted to e/m-Learning requirements. Section 4 is devoted to concluding remarks, open issues and future work.

2 FROM REALITY TO VISUAL PERCEPTION

Before detailing the layers between an image or video and its perception, let us consider a simple example, referred to the steps in Fig. 1; the example considers a virtual visit to a museum and makes a distinction between tourists and students. While the former can be generally considered experienced and properly equipped, the latter cannot always be provided with either fast network technologies or devices and have little experience in the field of fine arts.

Consider a museum (object); roughly speaking, the smart application represents and manages access to the masterpieces, so as to allow the user to visit them virtually. A visit can be enjoyed through the application interface, generally interactive. The perceived quality of service depends on several technical factors, such as how the museum was filmed, represented and stored, how fast information is transmitted and received, how fast interactions take place, etc. The application can include streaming videos, transmitted through a network infrastructure (for instance, a 100Mbps wired dorsal) and reaching the user through his or her network access technology (for instance, a WiFi on a 20Mbps DSL from home) on his or her mobile device. The device is defined by several properties, such as screen dimension and resolution.

In summary, the issues that must be taken into account are of two kinds: (i) **personal factors:** taste, age, previous knowledge, culture or experience about some masterpieces, expectations, attitude towards the fine arts or specific art movements or artists; (ii) **equipment:** network connection, devices. All such factors are also time-variant. As for personal factors, in fact, consider a masterpiece that hit you very deeply in the past, particularly well exposed. Suppose to see it again after many years in a poor context or showed through low-quality media: the effect is almost bound to be disappointing. On the contrary, in case you couldn't appreciate a seriously damaged painting, you will probably enjoy a digital restoration. In this case, the young are less probably experienced and influenced by memories than adults are.

As for equipment, the enjoyable and profitable fruition of high bandwidth-demanding contents, especially involving HD images or videos (such as HD 3D), makes the difference between properly equipped amateurs and most schools realities. On the one hand, in fact, both network technologies, such as Gigabit Ethernet (GbE) for wired connections and Long Term Evolution (LTE) for mobile communications, as well as powerful tablets are already on trade. On the other hand, such facilities are neither available worldwide nor at all the students' disposal.

Accompanied by an appropriate network load management and dynamic bandwidth distribution through QoS techniques, these fast connections and high-quality screens would surely allow a good enjoyment contents.

Also on the basis of the above considerations, Fig. 2 extends the representation in Fig. 1 to the case of visual perception. This depiction underlines once more that PQoS depends on both technical and personal factors and tries to detail some aspects of the process that leads from a real object to a user's visual perception. Fig. 2 can be ideally divided in three vertical areas. The arrows on the left represent the main phases of the whole process, classified in "acquisition", "transmission/delivery" and "personal elaboration". In the mid of Fig. 2, each phase is divided into its main components. On the right of Fig. 2, the ovals indicate whether the phase is lossy or enhancing, both from the technical and personal viewpoint. In more detail (Fig. 2, upper part from left to right), the acquisition process involves digital acquisition and storage of the represented object.

In such phases, the real object is filmed or photographed through videocameras or other devices, on the basis of the application needs and the photographer's personal interpretation. Such data are then stored, according to the application architecture. In particular, techniques such as photo restoration and digital compression are applied. In this sense, thus, the acquisition process can be lossy or enhancing from the technical viewpoint and is also personal, due to the photographer's or environmental mediation. As far as the transmission/delivery process is concerned (mid portion from left to right in Fig. 2), it involves the wired network infrastructure and the user's network access and device. Since every telecommunication system aims at the most complete transmission of the information received, data are transmitted in such a way to preserve quality. In consequence, the user will receive information in a period of time which depends on actual network speed and bandwidth at disposal. This can mean that, in case of slow connections or very rich contents, a HD video can reach the user with several interruptions, so as to make it not properly enjoyable or useless for a lesson. Further factors depend on the user's device, such as screen size and screen resolution. In this sense, the transmission/delivery phase can be technically lossy, even though it does not imply personal judgement. Such judgement will begin during the personal elaboration phase.

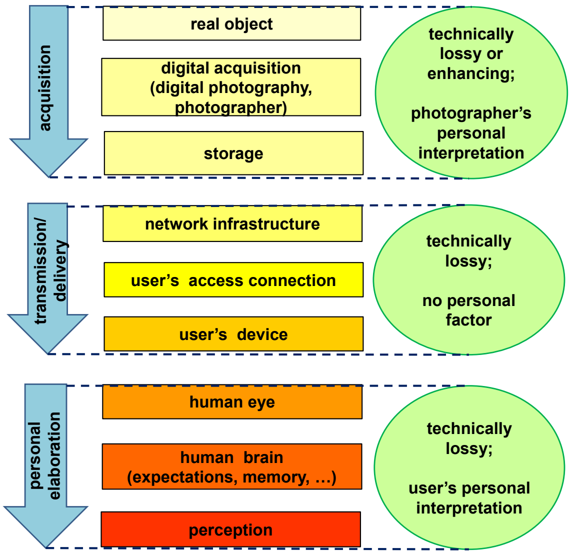

Figure 2: From the real object to perception.

As for the personal elaboration phase (bottom part of Fig. 2), the image or video reaches the human brain through the eyes and the complex process of perception takes place. This process is almost entirely personal, and can be considered a reconstruction based on genetic factors, environmental interactions and previous experiences (Arnheim, R., 1954, Ryan, 2005). This viewpoint is intentionally simplifying, but it can be useful when Smart Applications for the Cultural Heritage are considered. In this context, in fact, layers between real objects and human perception are particularly numerous and complicated.

As for PQoS, the whole system refers to the use of images and video streaming. The problem is particularly important when contents from the Cultural Heritage are involved.

PQoS is quite difficult to define and measure analytically. Still, some components can be identified. The following definitions try to give a contribute and simply intend to better characterize the problem.

PQoS is time-variant (PQoS = PQoS(t)) and, in the proposed approach, is a function of two components. The first is a technical component, here addressed to as TQoS = TQoS(t), which represents a time-dependent "Technical Quality of Service". TQoS varies over time for several reasons: think, for instance, that the quality of transmission depends on the bandwidth available, which is time-variant.

The second component is PQoS itself, a sort of personal factor, user's dependent and time-dependent, referred to the past, memorized in the brain, based on previous experiences, taste, expectations, etc. This component is here denoted by PQoS(t_{mem}), where t_{mem} roughly indicates a single instant, but comprehends all the times of memories, experiences, etc.

Let t_{now} be the current instant, when the image or video is being looked at. PQoS(t_{now}) can thus be represented as a recursive function f of TQoS(t_{now}) and PQoS(t_{mem}).

Expression E$_1$: PQoS(t_{now}) = f(TQoS(t_{now}), PQoS(t_{mem}))

According to the representation in Fig. 2, TQoS(t_{now}) can be better detailed.

Let [$t_{start\text{-}acq}$, $t_{end\text{-}acq}$] be the time interval during which the image was acquired and stored; [$t_{start\text{-}tra}$ - t_{now}] denotes the interval during which the image or video was transmitted to the user's device.

"Quality of Acquisition" can be denoted by QoA([$t_{start\text{-}acq}$, $t_{end\text{-}acq}$]); in the same way, the overall "Quality of Transmission" can be indicated as QoT([$t_{start\text{-}tra}$ - t_{now}]); The "Quality of the Device" used to look at the object is QoD(t_{now}).

In summary, TQoS(t_{now}), quality of service perceived at time t_{now}, can be denoted as a function g of its technical components:

Expression E$_2$: TQoS(t_{now}) = g(QoA([$t_{start\text{-}acq}$, $t_{end\text{-}acq}$]), QoT([$t_{start\text{-}tra}$ - t_{now}]), QoD(t_{now}))

The above expressions lead to:

Expression E$_3$: PQoS(t_{now}) = f(g(QoA([$t_{start\text{-}acq}$, $t_{end\text{-}acq}$]), QoT([$t_{start\text{-}tra}$ - t_{now}]), QoD(t_{now})), PQoS(t_{mem}))

Whereas PQoS(t_{mem}) is strictly personal, the technical quality of service can be handled with more precisely. In visual mobile applications, for instance, one of the most important quality factors to be guaranteed is the sense of continuity of a video. While very fast technologies, such as Gbps transmissions, provide users with this feature, the problem must be handled with in slower ones.

In the considered case, most school environments have or will have to cope with this problem for a long time.

The following Section takes two types of data (HD videos and non HD) into account, discusses the feasibility of an appropriate video enjoyment through different network access technologies and proposes a method for the dynamic management of bandwidth release on the basis of content size and duration.

3 PROPOSED ARCHITECTURE

The increasing availability of rich contents from the Internet will force to consider technical network aspects in e/m-Learning applications. Such activities, in fact, can involve high bandwidth demanding contents, such as HQ images or streaming videos from the Cultural Heritage and used in History of Art lessons.

The paper refers to different visual contents. In the observations, visual quality, such as number of interruptions, is considered. To this purpose, a long video was needed, in order to make more observations.

When a teacher prepares a lesson, he or she must be aware of possible problems in some students' connections and devices. For instance, the teacher can use a fast Internet connection, find a beautiful HD image or HD streaming video and decide to ask the pupils to see it. Some students, on their hand, can use slower connections when they follow the lesson from home, access the image or video and see them badly or with several interruptions. The risk, especially where visual quality is fundamental, is that such pupils are not able to follow the lesson properly.

In order to handle with this situation, a possible approach can be the following. On the one hand, the teacher must be prepared (and indicated) which contents he or she can use and which cannot, also on the basis of the students' technologies. On the other hand, an appropriate schedule of activities, made also on the basis of resources, can prevent the inappropriate fruition of lessons.

In Section 2, a distinction was made between TQoS and PQoS. The term TQoS includes several technical factors, among which the so called Quality of Service (QoS), as meant in Telecommunications. QoS refers to techniques and protocols for assigning bandwidth properly to single users or groups and guarantee the desired performance to data flows and services. In context of schooling applications, data flows must be handled with on the basis of the different activities scheduled over time. In particular, quality levels must meet the needs of teachers and allow all the students to enjoy profitable lessons from distinct locations and using heterogeneous access technologies.

Also due to the very severe lack of funding in several countries, advanced contents are not at everyone's disposal, so that ad hoc QoS techniques and scheduling methodologies must be adopted.

In the following, some QoS methodologies are briefly recalled. Then, some considerations are made about streaming videos. In particular, the feasibility of their use in History of Art lessons in e/m-Learning environments is addressed. An architecture is then proposed for dynamic and profile-based QoS management, based on duration and data rate predicted for a lesson.

In the following, the concept of QoS management is briefly summarized, in order to better explain the proposed variant.

The ever-growing request of bandwidth in mobile advanced applications, as well as the Digital Divide discrimination, are leading to the development of more and more efficient methodologies for bandwidth optimization. Several techniques have been developed, such as Traffic Shaping (Gringeri, S., 1998), Policy-Based Traffic Management (Conchon, E., 2010, Fangming Z., 2008, Heithecker, S., 2007) and Quality of Service (QoS) (Chang Wook, A., 2004, Huang, J.H., 2006).

In the considered e/m-Learning scenario, QoS priority-based dynamic profiles in wireless multimedia networks are considered. These techniques (Naser, H., 2005, Song, S., 2006) allow to assign different priorities to distinct applications, so as to rearrange service quality in a dynamic way (Kamosny, D., 2006) and guarantee the desired performance to data flows. Among such methods, the platform proposed and tested in (De Castro, C., 2011, Toppan, A., 2012) can manage simultaneously two levels of priority: (i) among different users and (ii) within a single user's connection. In (i), those users whose profiles guarantee higher bandwidth, are proportionally assigned a greater part of the shared bandwidth. Case (ii) refers to each user, whose distinct services are assigned distinct priorities on the basis of necessity. Each profile, in fact, allows the real-time management of services, and a sort of priority parameter is used to queue the desired applications properly. The testbed involved 80 users approximately. This method is at the basis of the proposed variant, designed to meet the needs of e/m-Learning environments. The idea is the following: students and the teacher, as a group, have specific users' profiles. In case a scheduled lesson requires peak bandwidth for a HD streaming video enjoyment in a given time interval, the system analyzes the students' network access technologies and decides whether the schedule can be accomplished or must be modified.

In the proposed approach, in particular, an **e/m-Learning System** and a **Traffic Control Center** interact. A first feasibility evaluation is made by the e/m-Learning System; a second phase is accomplished by the Traffic Control Center on the basis of information received from the e/m-Learning System.

Some preliminary measurements about video streaming quality in case of heterogeneous access technologies are here reported. When a teacher schedules a high bandwidth-demanding task, he or she can tell the system in advance the desired period of time during which a peak bandwidth requirement will take place and to whom the necessary bandwidth must be assigned.

In this way, the minimal bandwidth needed to accomplish the task can be evaluated and compared to the students' access technologies. Such evaluations can, for instance, rely on the simple numerical observations in Tab. 1.

Before describing these measurements, it must be observed that several and often unpredictable factors contribute to a mobile network connection speed, such as time, number of users connected, position, data rate, etc.

The apparently straightforward time access formula $t_{access} = D_{dim}/Net_{speed}$, where t_{access} represent the total access time, D_{dim} the data to be processed and Net_{speed} the network performance, is in fact only indicative. Each of its components depends on several, often time-variant factors. In particular, Net_{speed} varies over time and instantaneously.

Tab. 1 refers to a HD streaming motion picture and its non HD version. The film lasts about 105 minutes and is about 3GB in the HD version and 2GB in the non HD version. A long motion picture and no (generally shorter) specific content from the Cultural Heritage was used in order to make several observations during a long period. Some examples from the Cultural Heritage are cited and observed afterwards.

The effective measurements refer respectively to the HD and non HD versions accessed through: (i) a WiFi based on a wired 100Mbps (ii) a WiFi based on a 20 Mbps DSL and (iii) a 2Mbps GPRS.

Tab. 1 reports the total number of interruptions observed, but the discussion refers to the average. In case of 100 Mbps transmission, the data to be processed fits the network capability (0.9 interruptions per minute in the HD version and 0.6 in the non HD one). The streaming quality declines with 20 Mbps access technology (2 and 1.5 interruptions per minute respectively). In case of GPRS access, neither the HD nor the non HD videos are not even accessible.

A Gbps connection would allow an excellent streaming quality, as it already happens in North America with streaming TV, but it is quite rarely the case of schooling institutions and students all over the world.

Table 1: Network technology and streaming quality.

Data	Access	Quality
3GB	WiFi on 100Mbps	97 int./ 105 min.
2GB	WiFi on 100Mbps	60 int./ 105 min.
3GB	WiFi on 20Mbps	210 int./ 105 min.
2GB	WiFi on 20Mbps	160 int./ 105 min.
3GB	2Mbps	Not accessible
2GB	2Mbps	Not accessible

As anticipated, the above examples do not refer to contents from the Cultural Heritage, due to measurements needs but also to the risk of violating copyright. Some examples from the Cultural Heritage are reported in the following, with no image, and so are related observations . In particular, a self-portrait by Van Gogh (www. vangoghmuseum.nl/vgm/index.jsp?page=1728&collection=1285&lang=en, as of December 26th 2013) was first accessed through a low resolution screen and then through a good resolution smartphone. Despite the screen dimension, the effect was much better on the smartphone. Several interesting video contents from the Cultural Heritage are available at www.vimeo.com. In particular, the HD video at http://vimeo.com/47694417 (as of December 26th 2013) about a Silver Athenian Tetradrachma, lasted 1,32' and was accessed with no interruptions using a 100 Mbps, 1 interruption with a 20 Mbps DSL and 3 stops with a GPRS connection.

Talking about the architecture, dynamic bandwidth management methods aim at assigning bandwidth on the basis of different profiles, rights and actual needs. The proposed method simply tries to optimize bandwidth assignment on the basis of the activities planned during a lesson: when a teacher decides he or she wants to show his or her students some highly bandwidth-demanding contents, the early architecture proposed takes into account all the people involved and tries to manage the teacher's request.

A simple example can be the following: a lesson can involve an initial, introductory 15 minutes talk of the teacher to the students and, successively, a HD streaming video about 20 minutes long that the teacher has decided to show to his or her students.

During the first 15 minutes, no high bandwidth-demanding activity is involved (voice only), so bandwidth assignment profiles can be kept low. In the following 20 minutes, students need much more bandwidth; in order not to be displayed videos with several interruptions, their connections must be appropriate and their bandwidth profiles kept high.

In the proposed approach two kinds of feasibility controls are made, using information about the students' access technologies and network traffic predictions.

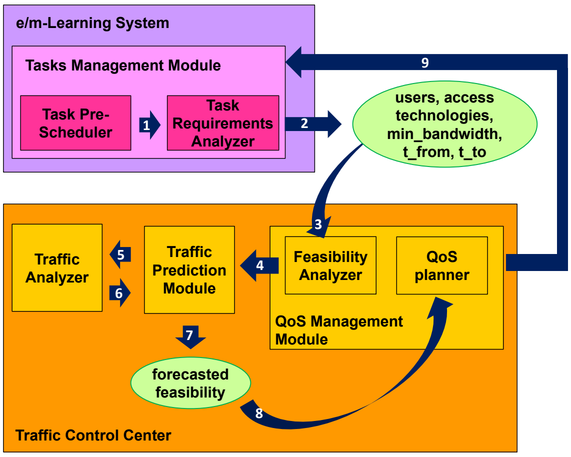

Figure 3: Proposed Architecture.

Fig. 3 illustrates the proposed architecture, in which the **e/m-Learning System** and the **Traffic Control Center** interact.

The e/m-Learning System contains several components, among which the **Task Management Module**, whose main sub-modules are the **Task Pre-Scheduler** and the **Task Requirements Analyzer**. The former collects the teachers' proposed schedules (step 1 in Fig. 3), the latter analyzes each task involved and, on the basis of the users' access technologies, makes a first feasibility evaluation, on the basis of the measurements reported above. In consequence, some students can simply be suggested to use their home DSL rather than GPRS from outside. This can be the case of a tablet which uses both technologies: WiFi from home DSL or the GPRS USIM. In the same way, if several students are bound to come across connection problems, the teacher can be asked whether a non HD version can meet his or her teaching needs.

This first phase accomplished, the Task Requirements Analyzer (step 2) returns the following data: users, their network access technologies, the minimal bandwidth to be guaranteed to everyone and the time interval [t_{from}, t_{to}] of the task.

This information (step 3) is forwarded to the **Traffic Control Center**, in particular to the **Feasibility Analyzer** of the **QoS Management Module**.

The Feasibility Analyzer forwards the information to the **Traffic Prediction Module** (step 4). This module interacts with the **Traffic Analyzer** (steps 5, 6) and the final decision ("forecasted feasibility" in step 7) is forwarded to the **QoS Planner** (step 8) and, finally, to the Task Management Module (step 9).

In particular, step 9 can be detailed as follows: in case the task is not forecasted as feasible, the e/m-Learning System is informed and the teacher can decide to decide a new schedule or accept lower-quality videos. In case the task is feasible, the QoS planner produces a QoS schedule and the e/m - Learning System is acknowledged.

4 CONCLUSIONS

In this paper, the use of advanced, visual contents in History of Art lessons was discussed from the viewpoint of visual quality. In particular, the concept was faced of visual perception of goods put at disposal by smart e/m-Learning applications using the Cultural Heritage, and so were the technical factors that contribute to the final perception were investigated. In this context, the problem becomes particularly relevant of image or video quality, especially if high-bandwidth demanding contents accessed in real-time are involved.

Two distinct but related aspects were discussed, concerning advanced visual contents from the Cultural Heritage and their use in smart education environments, referred to images and videos. The first was "Perceived Quality of Service" (PQoS) in visual environments. Second, the following problem was discussed: since learning contents can be accessed from home or outside using heterogeneous network access technologies (and, in consequence, different speeds), in a lesson involving high bandwidth-demanding contents, such as HD streaming virtual visits to museums, the bottleneck is data dimension. A possible solution to prevent teachers from selecting visual contents that run the risk of being inappropriately displayed by some pupils was proposed. The proposal, currently being under development phase, was an early architecture for the dynamic management of bandwidth release on the basis of content size and duration.

Further work will be devoted to a better definition of Perceived Quality of Service and its components, the role of memory and expectations and to a refinement of the proposed architecture.

ACKNOWLEDGEMENTS

The author wants to thank Prof. Gianni Pasolini (Telecommunications at DEI and WiLab, University of Bologna, Italy) for his kind and precious help.

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POMDP Framework for Building an Intelligent Tutoring System

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Keywords: Intelligent Tutoring System, Partially Observable Markov Decision Process, Reinforcement Learning.

Abstract: When an intelligent tutoring system (ITS) teaches its human student on a turn-by-turn base, the teaching can be modeled by a Markov decision process (MDP), in which the agent chooses an action, for example, an answer to a student question, depending on the state it is in. Since states may not be completely observable in a teaching process, partially observable Markov decision process (POMDP) may offer a better technique for building ITSs. In our research, we create a POMDP framework for ITSs. In the framework, the agent chooses answers to student questions based on belief states when it is uncertain about the states. In this paper, we present the definition of physical states, reduction of a possibly exponential state space into a manageable size, modeling of a teaching strategy by agent policy, and application of the policy tree method for solving a POMDP. We also describe an experimental system, some initial experimental results, and result analysis.

1 INTRODUCTION

An intelligent tutoring system (ITS) is a computer system that teaches a subject to human students, usually in an interactive manner. An ITS may work on a platform of a regular desktop or laptop computer, a smaller device like a mobile phone, or the Internet. ITSs have advantages of flexibility in scheduling and pace, and so on. ITSs will play an important role in computer based education and training.

An ITS performs two major tasks when it teaches a student: interpreting student input (e.g. questions), and responding to the input. In this research, we address the problem of how to choose the most suitable response to a question, when the tutoring is conducted in a form of question-and-answer.

Many subjects (e.g. software basics, mathematics) can be considered to include a set of concepts. For example, the subject of "basic software knowledge" includes concepts of *binary digit*, *bit*, *byte*, *data*, *file*, *programming language*, *database*, and so on. Understanding the concepts is an important task in studying the subject, possibly followed by learning problem solving skills. In teaching such a subject, an ITS must teach the concepts. Quite often, a student studies a subject by asking questions about the concepts.

In a subject, concepts are interrelated. Among the relationships between concepts, an important one is the *prerequisite* relationship. Ideally, to answer a student question about a concept, an ITS should first teaches all the prerequisites of the concept that the student does not understand, and only those prerequisites. If the ITS talks about many prerequisites that the student already understands, the student may become impatient and the teaching would be inefficient. If the ITS misses a key prerequisite that the student does not understand, the student may become frustrated and the teaching would be ineffective.

To decide how to teach a student about a concept, it is essential for the ITS to determine the right set of prerequisites to "make up". The decision depends on the student's study *state*. It can be seen that the selection of right system responses can be modeled by a Markov decision process (MDP).

In practical applications, the study state of a student may not be completely observable to the system. That is, the system may be uncertain about the student's study state. To enable an ITS to make a decision when information about a state is uncertain, we apply the technique of *partially observable Markov decision process* (*POMDP*). We create a POMDP framework for building an ITS, and develop a *reinforcement learning* (*RL*) algorithm in the framework for choosing the most suitable answers to student questions.

The novelty of our work includes techniques for efficiently solving POMDP and dramatically reducing the state space. The great complexity in solving POMDP and exponential state space are two major issues to address in applying POMDP to building ITSs.

In this paper, we describe the POMDP framework, including the representation of student study states by POMDP states, representation of questions and answers by POMDP actions and observations, our technique for dealing with the exponential state space, modeling of teaching strategy by an agent policy, and the policy tree method for solving the POMDP.

2 RELATED WORK

POMDP had been applied in education in 1990s. In an early survey paper (Cassandra, 1998), the work for using POMDP to build teaching machines was reviewed, in which POMDP was applied to model internal mental states of individuals, and to find the best ways to teach concepts.

Recent work related with using RL and POMDP for tutoring dialogues include (Litman and Silliman, 2004), (William et-al, 2005), (Williams and Young, 2007), (Folsom-kovarik et-al, 2010), (Thomson et-al, 2010), (Rafferty et-al, 2011), (Chinaei et-al, 2012), and (Folsom-Kovarik et-al, 2013). In the following, we review in more details some representative work.

In the work (Theocharous et-al, 2009), researchers developed a framework called SPAIS (Socially and Physically Aware Interaction Systems), in which Social Variables defined the transition probabilities of a POMDP whose states are Physical Variables. Optimal teaching with SPAIS corresponded to solving an optimal policy in a very large factored POMDP.

The paper of (Rafferty et-al, 2011) presented a technique of faster teaching by POMDP planning. The researchers framed the problem of optimally selecting teaching actions using a decision-theoretic approach and showed how to formulate teaching as a POMDP planning problem. They considered three models of student learning and presented approximate methods for finding optimal teaching actions.

The work in (Folsom-kovarik et-al, 2010) and (Folsom-Kovarik et-al, 2013) studied two scalable POMDP state and observation representations. State queues allowed POMDPs to temporarily ignore less-relevant states, and observation chains represent information in independent dimensions.

The existing work of applying POMDP to build ITSs was characterized by off-line policy improvement. The costs of solving POMDP and searching in an exponential state space created great difficulties in building systems for practical teaching tasks. In our research, we aim to developing more efficient techniques for solving POMDP and reducing the state space into a manageable size, and to achive online policy improvement.

3 RL AND POMDP

3.1 Reinforcement Learning

Reinforcement learning (RL) is an interactive machine learning technique (Sutton and Barto, 2005). In an RL algorithm, there is one or a group of learning agents, which learn knowledge through interactions with the environment. A learning agent is also a problem-solver. It applies the knowledge it learns to solve problems. Meanwhile, it improves the knowledge in the process of problem-solving.

The major components of an RL algorithm are S, A, T and ρ, where S is a set of states, A is a set of actions, T: $S \times A \times S \to [0,1]$ defines *state transition probabilities*, and ρ: $S \times A \times S \to \Re$ is the *reward function* where $\Re$ is a set of *rewards*.

At time step t, the agent is in state s_t, it takes action a_t. The action causes a state transition from s_t to a new state s_{t+1}. When the agent enters s_{t+1} at time step $t+1$, it receives reward $r_{t+1} = \rho(s_t, a_t, s_{t+1})$. The long term *return* at time step t is defined as

$$R_t = \sum_{k=0}^{n} \gamma^k r_{t+k+1} \qquad (1)$$

where $r_i \in \mathcal{R}$ is a reward ($i = t+1, t+2, ...$), and γ is a future reward *discounting factor* ($0 \leq \gamma \leq 1$).

An additional component is *policy* π. π can be used to choose the optimal action to take in a state:

$$\pi(s) = \hat{a} = \arg\max_a Q^\pi(s,a), \qquad (2)$$

where s is the state, $\hat{a}$ is the optimal action in s, and $Q^\pi(s,a)$ is the *action-value function* given π. It evaluates the expected return if a is taken in s and the subsequent actions are chosen by π:

$$Q^\pi(s,a) = \sum_{s'} P(s'|s,a) V^\pi(s') \qquad (3)$$

where s' is the state that the agent enters after it takes a in s, $P(s'|s,a)$ is the probability of transition from s to s' after a is taken, and $V^\pi(s)$ is the *state-value function* that evaluates the expected return of s given policy π:

$$V^\pi(s) = \sum_a \pi(s,a) \sum_{s'} P(s'|s,a)[\mathcal{R}(s,a,s') + \gamma V^\pi(s')] \qquad (4)$$

where γ is a future reward discounting factor, and $\mathcal{R}(s,a,s')$ is the *expected reward* when transiting from s to s' after a is taken.

3.2 Partially Observable Markov Decision Process

The RL discussed above is based on Markov decision process (MDP), in which all the states are completely observable. For applications in which states are not completely observable, POMDP may provide a better technique (Kaelbling et al., 1998).

The major components of POMDP are S, A, T, ρ, O, Z, and b_0. The first four are the same as the counterparts in RL. O is a set of *observations*. $Z : A \times S \to O$ defines *observation probabilities*, $P(o|a,s')$ denotes the probability that the agent observes $o \in O$ after taking a and entering s'. b_0 is the *initial belief state*.

POMDP is differentiated from MDP by the introduction of *belief state* denoted by b:

$$b = [b(s_1), b(s_2), ..., b(s_N)] \tag{5}$$

where $s_i \in S$ ($1 \leq i \leq N$) is the ith state in S, N is the number of states in S, $b(s_i)$ is the probability that the agent is currently in s_i and $\sum_{i=1}^{N} b(s_i) = 1$. To avoid confusion, we refer to an $s \in S$ as a *physical state*.

At a point of time, the agent is in a physical state $s \in S$. Since states are not completely observable, the agent has only the probabilistic information about the states that it is in. The information is represented by b, as given in (5). Based on b, the agent chooses action a to take. After taking a, the agent enters $s' \in S$ and observes o. The process is showed in Figure 1. The total probability for the agent to observe o after a is

$$P(o|a) = \sum_{s \in S} b(s) \sum_{s' \in S} P(s'|s,a) P(o|a,s'). \tag{6}$$

Action a causes a physical state transition: The agent enters s', which is not observable either. The state information available to the agent is a new belief state b'. Each element in b' is calculated as

$$b'(s') = \sum_{s \in S} b(s) P(s'|s,a) P(o|a,s') / P(o|a) \tag{7}$$

where o is what the agent observes after taking a, and $P(o|a)$ defined in (6) is used as a normalization constant so that the elements in b' sum to one.

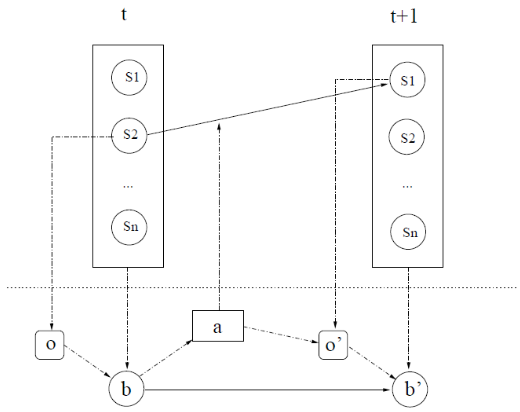

Figure 1: Physical states, belief states, actions, observations, and state transitions.

In POMDP, we use π to guide the agent to take actions. Differing from a policy in MDP, a policy in POMDP is a function of a belief state. The task to find the optimal policy is referred to as *solving a POMDP*.

The method of *policy tree* is used to simplify the process of solving a POMDP. In a policy tree, nodes represent actions, and edges represent observations. After the agent takes action a represented by a tree node, it observes o. The next action the agent will take is one of the children of a, connected by the edge representing o.

A policy tree is associated with a V function. In the following, we denote the V function of policy tree p as V_p. The value of physical state s given p is:

$$V_p(s) = \mathcal{R}(s,a) + \gamma \sum_{s' \in S} P(s'|s,a) \sum_{o \in O} P(o|a,s') V_{p(o)}(s') \tag{8}$$

where a is the root action of policy tree p, $\mathcal{R}(s,a)$ is the expected immediate reward after a is taken in s, o is the observation after a is taken, $p(o)$ is the subtree in p which is connected to the root action by an edge labeled o, and γ is a reward discounting factor. The second term in the expression on the right side of (8) is the discounted expected value of future states.

The value of belief state b is

$$V_p(b) = \sum_{s \in S} b(s) V_p(s). \tag{9}$$

For belief state b, there is an optimal policy tree p, which maximizes the value of the belief state:

$$V(b) = \max_{p \in \mathcal{P}} V_p(b) \tag{10}$$

The policy $\pi(b)$ (approximated by a policy tree) is a function of b, returning a policy tree that maximize the value of $V(b)$:

$$\pi(b) = \hat{p} = \arg\max_{p \in \mathcal{P}} V_p(b) \tag{11}$$

4 INTELLIGENT TUTORING SYSTEM ON POMDP

4.1 An Overview

We cast our ITS onto the framework of RL and POMDP. The main components of the ITS include states, actions, observations, and a policy. The states represent the student's study states: what the student understands, and what the student does not understand. The actions are the system's responses to student input, and the observations are student input, including questions. The policy represents the teaching strategy of the system.

At a point of time, the learning agent is in state s, which represents the agent's knowledge about the student's study state. Since in practical applications, the knowledge is not completely certain, we calculate belief state b for the knowledge. b is a function of the previous belief state, previous system action (e.g. answer), and the immediate student action (e.g. question) just observed by the agent. To respond to the student action, policy $\pi(b)$ is used to choose the most suitable system action a, for example, the answer to the student question.

After seeing system action a, the student may take another action, treated as observation o. Then new belief state b' is calculated from a and o, and the next system action is chosen by $\pi(b')$, and so on.

4.2 States: Student Study States

In teaching a student, the knowledge about the student's study state is essential to choose a teaching strategy. By *study state*, we mean what concepts the student understands and what concepts the student does not understand. We define the states in the POMDP to represent student study states.

As mentioned, a subject includes a set of concepts. For each concept C, we define two conditions:

- the *understand* condition, denoted by $\surd C$, indicating that the student understands C, and
- the *not understand* condition, denoted by $\neg C$, indicating that the student does not understand C.

We use expressions made of $\surd C$ and $\neg C$ to represent study states. For example, we can use expression $(\surd C_1 \surd C_2 \neg C_3)$ to represent that the student understands concepts C_1 and C_2, but not concept C_3.

A state is associated with an expression made of $\surd C$ and $\neg C$. We call such an expression a *state expression*. A state expression specifies the agent's knowledge about the student's study state. For example, when the agent is in a state associated with expression $(\surd C_1 \surd C_2 \neg C_3)$, the agent has the knowledge about the concepts that student understands and does not understands. When the subject taught has N concepts, each state expression is of the form

$$(\mathcal{C}_1 \mathcal{C}_2 \mathcal{C}_3 ... \mathcal{C}_N), \tag{12}$$

where $\mathcal{C}_i$ takes $\surd C_i$ or $\neg C_i$ $(1 \le i \le N)$.

The major advantage of this state definition is that each state has the most important information required to teach the student – the study state. In addition, the states thus defined are Markovian. The information required for choosing a system response is available in the state that the agent is in.

4.3 Dealing with the Exponential State Space

As mentioned, when there are N concepts in the subject taught by the ITS, a state expression is of the form $(\mathcal{C}_1 \mathcal{C}_2 \mathcal{C}_3 ... \mathcal{C}_N)$, where $\mathcal{C}_i$ takes $\surd C_i$ or $\neg C_i$ $(1 \le i \le N)$. Thus we have 2^N possible state expressions, which is exponential. However, the actual number of states is much smaller than 2^N. The reason is that most expressions are for invalid states. For example, $(\surd C_1 \neg C_2 \surd C_3 ...)$ is for an invalid state when C_2 is a prerequisite of C_3. Assume that C_2 is "bit" and C_3 is "byte". The expression represents an invalid state in which a student understands "byte" without knowledge of "bit", which is a prerequisite of "byte".

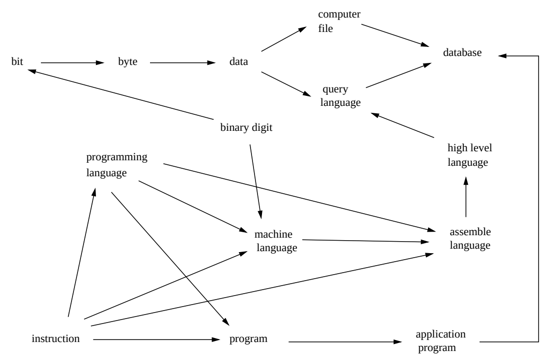

Figure 2: A DAG showing prerequisites between concepts.

To deal with the exponential space, we use the relationship of concept prerequisites in encoding state expressions. The relationship helps eliminate invalid states and maintain a state space of a manageable size. Let C_1 and C_2 be two concepts in a subject. If to understand concept C_2, a student must first understand C_1, we say C_1 is a prerequisite of C_2. A concept may have one or more prerequisites, and a concept may serve as a prerequisite of one or many other concepts. The concepts and their prerequisite relationships can be represented in a directed acyclic graph (DAG). Figure 2 is such a DAG for a subset of concepts in basic software knowledge.

When encoding state expressions in the form of (12), we perform a topological sorting on the DAG, to generate a 1-D sequence of the concepts. For example, the following is a topologically sorted sequence of the concepts in the DAG in Figure 2:

BD BI BY DA FI IN PL ML AL HL QL PR AP DB

where BD stands for "binary digit", BI for "bit language", BY for "byte", DA for "data", FI for "file", IN for "instruction", PL for "programming language", ML for "machine language", AL for "assembly language", HL for "high-level language", QL for "query language", PR for "program", AP for "application program", and DB for "database".

In a topologically sorted state expression, all the direct and indirect prerequisites of a concept are on the left hand side of it. The sorting helps determine invalid states. For example, $(\surd C_1 \neg C_2 \surd C_3 ...)$ is for an invalid state when C_2 is a prerequisite of C_3. In a state expression, if the jth concept is in $\surd C_j$ condition, and there exists a prerequisite left to it, e.g. the ith concept, which in condition $\neg C_i$, we can determine that the state is invalid by using simple calculation.

Let C_{j1}, C_{j2}, ... C_{jN_j} be the set of prerequisites of C_j. We call $C_{j1}C_{j2}...C_{jN_j}C_j$ the *prerequisite sequence* of C_j. A prerequisite sequence is in a valid condition, if and only if when concept C_k in the sequence is $\surd C_k$, any concept C_i to its left is $\surd C_i$. A state expression made of N concepts has at most N prerequisite sequences, and each of the prerequisite sequences has at most N valid conditions. We can thus estimate that the maximum number of valid states is N^2.

4.4 Definition of Actions

In a tutoring session, asking and answering questions are the primary actions of the student and system. Other actions are those for confirmation, etc.

We classify actions in the ITS into *student actions* and *system actions*. Student actions mainly includes the actions of asking questions about concepts. Asking "what is a database?" is such an action. Each student action involves only one concept. In the following discussion, we denote a student action of asking about concept C by $[C]$.

The system actions mainly include the actions of answering questions about concepts, like "A database is a collection of interrelated computer files and a set of application programs in a query language". We use $\{C\}$ to denote a system action of explaining C.

Quite often, the system can answer $[C]$ directly by taking the action of $\{C\}$. However, sometimes to answer a question, the system has to "make up" some prerequisite knowledge. For example, before answering a question about "database", the system has to explain "query language" and "computer file" if the student does not understand them. Let's use C_l represent "database", C_j represent "query language", and C_k represent "computer file" ($1 \leq j < k < l$), and assume $j < k$. Subscripts j, k, l are indexes of the concepts in the state expressions, which are topologically sorted. We express such actions as $\{C_jC_kC_l\}$, which specifies that the system explains C_j, then C_k, and then C_l. It explains C_j and C_k in order to eventually explain C_l. In the following discussion, we refer to such a sequence of actions for answering a question as a *answer path*.

5 OPTIMIZATION OF TEACHING STRATEGY

5.1 Teaching Strategy as Policy Trees

As discussed, when answering a question about a concept, an ITS may directly explain the concept, or it may start with one of the prerequisites to make up the knowledge that is needed for the student to understand the concept in question. In this paper, *teaching strategy* is used to select of the starting concept in answering a question. The teaching strategy largely determines student satisfaction and teaching efficiency.

A question can be answered in different ways. Assume the student question is $[C_k]$ and C_k has prerequisites C_1, C_2, ..., C_{k-1}. A possible system action is to teach C_k directly, without making up a prerequisite. The second possible action is to start with C_1, then teach C_2, until C_k. The third action is to start with C_2, then teach C_3, until C_k, and so on. For example, when asked about "database", the agent may explain what a database is, without making up any prerequisite. A disadvantage is the student may become frustrated and has to ask about many prerequisites. Another answer is to start with a very basic prerequisite. A disadvantage of this answer is low efficiency and the student may become impatient. When answering a student question, the system should choose a answer which starts with the "right" prerequisite if the concept in question has prerequisites.

We model the teaching strategy as the policy. In POMDP, policy trees can be used to simplify the process of POMDP solving, that is, the process to find the optimal policy. In a policy tree, a node represents an action and an edge represents an observation. When executing a policy tree, the system first takes the action at the root node, then depending on the observation, takes the action at the node that is connected by the edge representing the observation, and so on.

A policy is comprised of a set of policy trees. When we use POMDP to solve a problem, we select the policy tree that maximizes the value function. For different belief state b, we choose different policy trees to solve the problem. The calculation for policy selection is given in Eqn (11).

For each concept, we create a set of policy trees to answer questions about the concept. Let the concept in question be C_l. For each *direct* prerequisite C_k, we create a policy tree p with C_k being the root. In the policy tree, there is one or more paths $C_k, ..., C_l$, which are *answer paths* for student question $[C_l]$. When the student asks a question about C_l, we select the policy tree p that contain the most suitable answer path, based on the student's current study state.

5.2 Policy Initialization

From (11), (9), (10), and (8), we can see that a policy is defined by the V function, and the V function is defined by $\mathcal{R}(s,a)$, $P(s'|s,a)$, and $P(o|a,s')$. The creation of $\mathcal{R}(s,a)$, $P(s'|s,a)$, and $P(o|a,s')$ is the primary task in policy initialization. $\mathcal{R}(s,a)$ is the expected reward after the agent takes a in s. We define the reward function as $S \times A \to \mathfrak{R}$, and have $\mathcal{R}(s,a) = \rho(s,a)$, which returns rewards depending on if action a taken in state s is accepted or rejected by the student. More about rejection and acceptance of a system action will be given in the discussion of experimental results.

Policy initialization mainly involves creating $P(s'|s,a)$ and $P(o|a,s')$. We will see that updating them is also the primary task in policy improvement.

$P(s'|s,a)$ is defined as

$$P(s'|s,a) = P(s_{t+1} = s'|s_t = s, a_t = a) \tag{13}$$

where t denotes a time step, and s' is the new state at time step $t+1$. $P(o|a,s')$ is defined as

$$P(o|a,s') = P(o_{t+1} = o|a_t = a, s_{t+1} = s') \tag{14}$$

where t and $t+1$ are the same as (13).

To initialize $P(s'|s,a)$ and $P(o|a,s')$, we create action sequences as training data. The data are represented as tuples:

$$...(\breve{s}_t, a_t, o_t, \breve{s}_{t+1})(\breve{s}_{t+1}, a_{t+1}, o_{t+1}, \breve{s}_{t+2})... \tag{15}$$

where the a denoted a system action, and o denotes a student action since the agent treats a student action as an observation.

Let s be $\breve{s}_t$, and s' be $\breve{s}_{t+1}$. $P(s'|s,a)$ and $P(o|a,s')$ can be initialized as

$$P(s'|s,a) = \frac{|\text{transition from } s \text{ to } s' \text{ when } a \text{ is taken in } s|}{|a \text{ is taken in } s|}, \tag{16}$$

$$P(o|a,s') = \frac{|a \text{ is taken, } s' \text{ is perceived, } o \text{ is observed}|}{|a \text{ is taken and } s' \text{ is perceived}|}, \tag{17}$$

where $|\ |$ is the operator for counting. In (16) and (17) the counts are from the training data in the form of (15).

5.3 Policy Improvement

Policy improvement updates $P(s'|s,a)$ and $P(o|a,s')$, so that belief states can model physical states better. The objective of policy improvement is to enable the agent to choose more understandable and more efficient answers to student questions.

In reinforcement learning, the learning agent improves its policy through the interaction with the environment, and the policy improvement is conducted when the agent applies the policy to solve problems.

We use a delayed updating method for policy improvement. In this method, the current policy is fixed for a certain number of tutoring sessions. In the sessions, system and student actions are recorded. After the tutoring sessions, while the policy continues to work, information about the recorded actions is processed, and the transition probabilities and observation probabilities are updated. When the improvement is completed, the updated probabilities replace the current ones and are used for choosing system actions, then they are updated again after a certain number of tutoring sessions, and so on.

The recorded data for policy improvement are sequences of tuples. In the tuples, we use a to denote a system action and o to denote a student action. The recorded data are

$$...(\hat{s}_t, a_t, o_t, \hat{s}_{t+1})(\hat{s}_{t+1}, a_{t+1}, o_{t+1}, \hat{s}_{t+2})... \tag{18}$$

where $\hat{s}_i$ is the most probable physical state in b_i ($i = 1, ..., t, t+1, ...$). At time step i, the agent believes that it is most likely in $\hat{s}_i$. In the following, we call $\hat{s}$ the *believed physical state*.

The recorded tuple sequences are modified for updating the probabilities. We modify believed physical state $\hat{s}_{t+1}$ by using student action o_t. Here we use tuple $(\hat{s}_t, a_t, o_t, \hat{s}_{t+1})$ to explain the modification. Assume $o_t = [C_l]$, and the expression of $\hat{s}_{t+1}$ is $(...\surd C_j \surd C_k \neg C_l...)$ where C_j and C_k are prerequisites of C_l. That is, the student asks a question about C_l, and to the agent, the student is in a study state of not understanding C_l but understanding C_j and C_k. If in the subsequent tuples in the same recorded tutoring session there are student actions of $o_{t+1} = [C_j]$ and $o_{t+2} = [C_k]$, we modify the expression of $\hat{s}_{t+1}$ into $(...\neg C_j \neg C_k \neg C_l...)$, which is for a state in which the student does not understand the three concepts. This is a different state. We thus modify the tuple into $(\hat{s}_t, a_t, o_t, \breve{s}_{t+1})$, where $\breve{s}_{t+1}$ is the state represented by $(...\neg C_j \neg C_k \neg C_l...)$. In the following, we use $\breve{s}$ for the states in the modified tuples.

After the modification, the tuple sequences for updating the probabilities become

$$...(\breve{s}_t, a_t, o_t, \breve{s}_{t+1})(\breve{s}_{t+1}, a_{t+1}, o_{t+1}, \breve{s}_{t+2})... \tag{19}$$

From (19), we derive sequence

$$...(\breve{s}_t, a_t, \breve{s}_{t+1})(\breve{s}_{t+1}, a_{t+1}, \breve{s}_{t+2})... \tag{20}$$

for updating $P(s'|s,a)$, and derive sequence

$$...(a_t, o_t, \check{s}_{t+1})(a_{t+1}, o_{t+1}, \check{s}_{t+2})... \qquad (21)$$

for updating $P(o|a,s')$.

$P(s'|s,a)$ is updated as

$$P(s'|s,a) = C_1/(C_2+C_4) + C_3/(C_2+C_4) \qquad (22)$$

where

- C_1 is the accumulated count of tuples (s,a,s') in which $s = \check{s}_t$, $a = a_t$ and $s' = \check{s}_{t+1}$ in initialization and all the previous updates.
- C_2 is the accumulated count of tuples $(s,a,*)$ in which $s = \check{s}_t$, $a = a_t$, and $*$ is any state in initialization and all the previous updates.
- C_3 is the count of tuples (s,a,s') in which $s = \check{s}_t$, $a = a_t$ and $s' = \check{s}_{t+1}$ $a_t = a$ and $\check{s}_{t+1} = s'$ in the current update.
- C_4 is the count of tuples $(s,a,*)$ in which $s = \check{s}_t$, $a = a_t$, and $*$ is any state and $a_t = a$ in the current update.

$P(o|a,s')$ is updated in the same way.

6 EXPERIMENTS AND RESULTS

6.1 Experimental System

An experimental system has been developed for implementing the techniques. It is an interactive ITS for teaching basic software knowledge. It teaches software knowledge in terms of about 150 concepts. The system teaches a student at a time on a turn-by-turn basis: The student asks a question about a concept, and the system answers the question, then based on the system answer the student asks a new question or asks a question for understanding the concept just questioned, and the system answers, and so on. The student communicates with the system by using a keyboard, and the system's output device is the screen. The ITS is a part of a larger project of a spoken dialogue system (SDS). Using the keyboard and screen for input and output allows us to focus on the development and improvement of the teaching strategy, without considering issues in speech recognition.

The main components of the system include a student module, an agent module, and a collection of databases. The student module is responsible for interpreting student input and converting it into a form usable to the agent module. (The student module and the input interpretation function are not discussed in this paper because of the limitation of paper length.) The agent module is the dialogue manager. For a student input (mostly a question), the agent module invokes policy $\pi(b)$ to choose the most suitable response.

The databases are the *system action database* storing human understandable system responses (answers), *policy tree database* storing policy trees for solving POMDP, *transition probability database* storing $P(s'|s,a)$, *observation probability database* storing $P(o|a,s')$, and *reward database* storing $\mathcal{R}(s,a)$.

6.2 Experiment

30 people participated in the experiment. In the following, we call them students. The students know how to use desktop or laptop computers, Windows or Mac operating systems, and application programs like Web browsers, word processors, and so on. They did not have formal training in computer science and software development.

The 30 students were randomly divided into two groups of the same size. The students in Group 1 studied with the ITS which did not have the improved teaching strategy. When a student asked about a concept, the system either explained the concept directly, or randomly chose a prerequisite to start. The students in Group 2 studied with the ITS in which the teaching strategy was continuously improved.

The ITS taught a student at a time. Each student studied with the ITS for about 45 minutes. For each student, the question-answer sessions were recorded for performance analysis.

The performance perimeter is *rejection rate*. Roughly, if right after the system explains concept C, the student asks a question about a prerequisite of C, or says "I already know C", we consider the student rejects the system action. For a student session, the rejection rate is defined as the ratio of the number of system actions rejected by the student to the total number of system actions.

6.3 Result Analysis

We applied a two-sample t-test method to evaluate the effects of the optimized teaching strategy to the teaching performance of an ITS. The test method is the *independent-samples t-test* (Heiman, 2011).

For each student, we calculated the mean rejection rate. For the two groups, we calculated means $\bar{X}_1$ and $\bar{X}_2$. Sample mean $\bar{X}_1$ is used to represent population mean μ_1, and $\bar{X}_2$ represent μ_2.

The alternative and null hypotheses are:

$$H_a : \mu_1 - \mu_2 \neq 0, \qquad H_0 : \mu_1 - \mu_2 = 0$$

The means and variances calculated for the two groups are listed in Table 1. In the experiment, n_1=15

Table 1: Number of students, mean and estimated variance of each group.

	Group 1	Group 2
Number of students	$n_1 = 15$	$n_2 = 15$
Sample mean	$\bar{X}_1 = 0.5966$	$\bar{X}_2 = 0.2284$
Estimated variance	$s_1^2 = 0.0158$	$s_1^2 = 0.0113$

and n_2=15, thus the degree of freedom is $(15-1)+(15-1) = 28$. With alpha at 0.05, the two-tailed t_{crit} is 2.0484 and we calculated $t_{obt} = +8.6690$. Since the t_{obt} is far beyond the non-reject region defined by $t_{crit} = 2.0484$, we should reject H_0 and accept H_a.

As listed in Table 1, the mean rejection rate in Group 1 was 0.5966 and the mean rejection rate in Group 2 was 0.2284, and the accepted alternative hypothesis indicated the difference between the two means was significant. The analysis suggested that by using the optimized teaching strategy, the rejection rate has been reduced from 0.5966 to 0.2284.

7 CONCLUSIONS

In teaching a student, an effective teacher should be able to adapt a suitable teaching strategy based on his/her knowledge about the student's study state, and should be able to improve his/her teaching when becoming more experienced. An effective ITS should have the same abilities. In our research, we attempt to build such an ITS. Our approch is POMDP.

Our research has novelty in state definition, POMDP solving, and online strategy improvement. The state definition allows important information to be available locally for choosing the best responses, and reduces an exponential space into a polynomial one. Compared with the existing work for applying RL and POMDP to build ITSs, which mainly depend on off-line policy improvement, our online improvement algorithm enables the system to continuously optimize its teaching steategies while it teaches.

ACKNOWLEDGEMENTS

This research is supported by the Natural Sciences and Engineering Research Council of Canada (NSERC).

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Learning Design for Software Engineering Courses

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Keywords: Learning Design, Software Engineering, Course Design.

Abstract: This paper presents a customization of a learning design approach, OULDI, to designing and implementing Software Engineering courses. We propose an iterative process for the application of the OULDI views. This process starts with a course map view and follows a series of steps that ends with the evaluation of the design reflecting on the balance of the proposed activities. A case study is presented in which two institutions were involved in the design and implementation of an experimental software engineering course. Feedback from students, designers and lecturers was collected to support the validation of the design and implementation of the course. This showed that learning design, with the process proposed here, is a feasible approach for the design of software engineering courses.

1 INTRODUCTION

Information and Communication Technology (ICT) resources that have been used predominantly in distance education to improve the experience of the learner are now available at lower costs and finding their way into many educational contexts. This wide use calls for strategies to integrate ICT resources in the learning process that take into account different educational modes and different domains.

Education has always required planning and design; however, in a face-to-face context, learning relies often on implicit practice. The widespread use of ICT and the opening of new educational practices, for example, the integration of distance education elements and of open educational resources, make a stronger demand on support for preparation and planning. Learning design is an approach that supports teachers and designers to make informed decisions about course activities, resources, technologies and pedagogical approaches (Conole, 2013). Learning design can be used at different levels of granularity, from the representation of learning activities that are performed by different actors in the context of a course, to the planning of curriculum for whole programmes (Koper, 2006). When learning design is applied to develop a course, it allows for the sharing, discussion, validation and evolution of the course designs; when applied to activities it will facilitate the discussion of their learning outcomes and pedagogical approaches. Both the process of planning and the product of that planning can be made explicit through design representations supported by methods and tools.

In the design of a software engineering course, pedagogical decisions are influenced by the nature of professional activities. These require specific skills that can be strengthened by the activities, and the experiences that students engage with. The teaching of technical skills needs to be integrated with that of soft skills such as: cooperation and effective communication, leadership, negotiation, feasibility analysis, and adaptation to new models and technologies. Learning design can facilitate this integration through planning activities that promote the dialogue between learners and educators. Learning design has similarities with software engineering in terms of making abstractions and models explicit before implementation (Caeiro-rodríguez et al., 2010). The core of a software engineering course is about learning to extract requirements from stakeholders and the real world and making them explicit in a design language and in code (Sommerville, 2010). One such language, the Unified Modelling Language (UML) (OMG, 2013), has also been referred to as a design tool in learning design (Dalziel, 2012; Grainne Conole, 2013). Both software designers and educators rely extensively on their prior experience and context for development (Wilson, 2007). This highlights commonalities between learning and software engineering design techniques that should be exploited further.

Several research projects developed tools to support learning design (Koper, 2006; Dalziel, 2012). The Open University Learning Design Initiative (OULDI) is such a project that developed a set of concepts together with computer-supported tools (Cross et al., 2012). It supports explicit course design representations and provides mechanisms to foster sharing of material and collaboration amongst course team members.

In this paper, we propose a customisation of OULDI for software engineering education. This customisation includes an explicit design process conceived to organise the development of the views proposed by OULDI. We applied this customisation to the design and implementation of an Experimental Software Engineering (ESE) course, in the context of a master program in Computer Science.

The paper is organized as follows. Section 2 gives the background for this work. Section 3 presents the customised OULDI process. Section 4 describes a case study in which an ESE course was designed and implemented by two institutions in Brazil with the collaboration of the Open University, UK. Section 5 discusses the feedback from designers, lecturers and students. Section 6 presents conclusions and further work.

2 BACKGROUND

Learning design as a research field has emerged in the last 10 years mainly from researchers in Europe and Australia (Koper 2006; Grainne Conole, 2013; Dalziel, 2012). It has a strong emphasis on making the design process and artefacts explicit and shareable. Design in education is not a new field though, and instructional design has been a well-established discipline for several decades (Eckel, 1993). However, learning design takes a broader approach, moving away from the production of instructions derived from learning goals, towards a more learner centred approach that is dynamic and takes into account a supporting environment and all stakeholders involved in planning the learning process; it builds also on research on learning sciences and design languages.

The learning design process and representation can be considered as pedagogically neutral as they can be used to represent the activities, tools and roles of any pedagogical approach. In this sense, learning design is more flexible than instructional design; it provides a framework where different pedagogical approaches can be implemented.

Our work is based on OULDI (Conole, 2013; Cross et al., 2012). It supports the design of courses with views, guidelines and tools. It allows the structured design of activities and their articulation with the learning outcomes, content and tools in such a way that the educators can envision the overall course to make decisions and carry out necessary adjustments before proceeding to production. It also provides a set of support tools, namely: CompendiumLD (CompendiumLD, 2008) which is a workflow design tool that contains special templates for course designs; and Cloudworks (Conole and Cuvel, 2009), that provides an open public space to which users can contribute, and where they can discuss learning and teaching designs and experiences. We chose to work with OULDI because of the set of support tools and its ease of use for higher education and for designers who are familiar with technology. Approaches, such as CADMOS (Katsamani and Retalis, 2008), LDSE (Laurillard et al., 2011) and LAMS (Dalziel, 2009) provide similar resources, but are more self-contained environments which would be difficult to customize. Their tools are also more directed to school teachers; our purpose is to support software engineering educators who are used to work with workflow techniques similar to the approach supported by CompendiumLD. We are aware that the OULDI has evolved and added more support mechanisms like the course features cards (Cross et al., 2012) but we did not incorporated them at this stage.

3 LEARNING DESIGN IN SOFTWARE ENGINEERING

OULDI (Cross et al., 2012) provides a set of shareable artefacts of design that represents a course around five conceptual views. These views are: (i) a `course map` which represents an overview of the course; (ii) a `course dimension`, which gives detail on the nature of the course (collaboration, assessment, user content, etc); (iii) a `pedagogy profile` which indicates the learners' participation in the designed types of activities; (iv) the `learning outcomes map` which links these to activities and assessment; and (v) the `task swimlane` which relates tasks to resources and tools. OULDI promotes an iterative approach of problem identification, solutions development, use, evaluation and refinement, but does not define an explicit design process. With our software engineering background and expertise we felt the need for a more detailed process to the application of OULDI to the design of courses in the software engineering domain. We detailed a process where the OULDI views are iteratively developed in three phases, as shown in Figure 1, and described below.

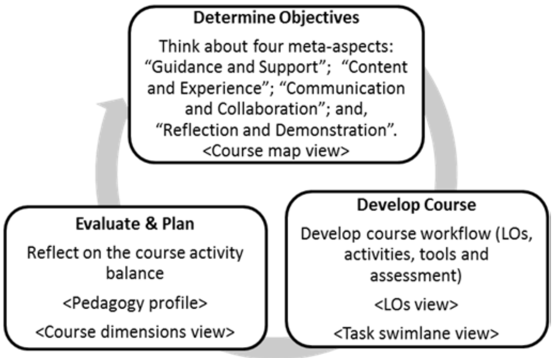

Figure 1: OULDI adapted process.

`Determine Course Objectives`: produces the course map view which is the first overview of the course. This helps educators think about the design of the course around four aspects: (i) Guidance & Support; (ii) Content & Experience; (iii) Communication & Collaboration; and, (iv) Reflection & Demonstration. Inputs to this phase are the course context and the ideas and objectives discussed by the course team.

`Develop Course`: develops the sequence of course activities generating the Learning Outcomes (`LOs`) and task swimlane view. Activities can be developed at hierarchical levels starting from composed activities and going down to atomic tasks. Activities and tasks can be associated with roles, tools and course material.

`Evaluate & Plan`: reflects on the balance of the activity types of the course to evaluate the design and evolve it. The designers have to establish the amount of each type of activity and the amount of assessment. This information produces the pedagogy profile and course dimension views. The pedagogy profile classifies the activities into: (i) Assimilative, attending and understanding content; (ii) Finding and handling information, gathering and classifying resources or manipulating data; (iii) Interactive and adaptive, using modeling or simulation software; (iv) Communicative**,** carrying out dialogic activities (e.g., group-based discussions); (v) Productive, constructing an experimental study; (vi) Experiential, practicing skills in the context of an experiment; and, (vii) Assessment, performing formative and summative evaluations.

Each phase produces a set of outputs which can be used in the next phase and refined iteratively. The availability of these artefacts facilitates the process of collaborative design of the learning experience.

4 CASE STUDY: THE ESE COURSE

The design of the ESE course was carried out taking into account the context of a master's program in Computer Science and a Brazilian multi-institutional project, funded by PROCAD/CAPES (www.capes.gov.br), whose objectives included the offer of collaborative courses. In Brazil, master's programmes are research driven programs where students engage with the development of new ideas and the proposal of new approaches (Barroca and Gimenes, 2013).

ESE is a subarea of software engineering focusing on the evidence of validity of methods and tools (Kitchenham et al., 2002). It is an important topic to teach in postgraduate computer science (and software engineering) programs geared to research; students need to provide evidence of the feasibility of proposed new methods and tools.

4.1 Course Design

The design of the ESE course started with the **`Determine Course Objectives`** phase by understanding the course context and educators's intentions and constraints. An ESE course teaches principles and techniques for evaluation applied to software engineering. It should instigate students to discuss collectively the value and means of evaluating research methods, tools and experiments. Students need to learn a well-defined process ranging from the planning of an experiment to its packaging for replication (Wohlin, 2000). This process should be supported by statistical methods to guide data collection and analysis. The course has to make sure that the theoretical principles are well understood, and that there are opportunities for learning and practising the development and replication of practical studies. Group work should be encouraged and supported. It is important to learn that the participation of individuals with an appropriate profile in the experiments is valuable to enhance the meaning of the collected data, thus improving confidence in the results. It is often the case that experiments involve more undergraduate and graduate students than practitioners. Therefore, the course should seek to involve external participants, mainly from industry, in the execution of the experiments. Students should be aware of existing tools to select and use in their experimental studies. The students should learn how to package their experiments for replication. As a result of the phase **`Determine Course Objectives`** the ESE Course map view was produced as described in Table 1.

Table 1: ESE Course map view.

Guidance & Support	Content & Experience
15 weeks (August to December 2012), 30 hours, 2 credits 2 hours of classes plus 4 hours of study per week which leads to a total of 90 hours Theory but more practice Course team and tutors Google (Website, Calendar, Wikis, Document sharing)	Existing text books: Wohlin , Juristo and Moreno Selected papers and theses Study guides Activities in the study guides Data collection and analysis
Reflection & Demonstration	**Communication & Collaboration**
Brainstorming of research evaluation Essays Small exercises Replication of an experiment Design and conduction of an experiment with result discussion Packing of an experiment Learning journal Self-assessment questions Formative and summative assessments Final examination	News Alerts for meetings and deadlines Work in groups, peer-to-peer and group discussions, log of discussions Google+ to support networks of experimental studies Network of experimental studies involving external participations from industry and postgraduate programs

The **`Develop Course`** phase designed the course activities taking as input the ESE course map view. It produced the `LOs` view of the ESE course in hierarchical levels as shown in Figures 2 and 3.

The 1st level of the `LOs` view consists of three activities: `Main Activities`; `Discussions`; and `Keep a Network of Participants`. Each activity is associated with roles, resources and tools which are represented in Figure 2 with the respective CompendiumLD icons. The activity `Discussions` is designed to aggregate students into groups to exchange ideas and carry out course assessments. The activity `Keep a Network of Participants` is designed to maintain a network of people who can act as participants in the course experiments.

The `Main activities` were further detailed, in a 2nd level, as shown in Figure 3. It shows lower granularity activities which compose the core of the course. In this figure we can see four CompendiumLD stencils: (i) `What is to be learnt` marking the line of `LOs`; (ii) `Student activity` for course activities; (iii) `Media and tools` for tools used in the activities; and (iv) `Learning output` for Summative Assessments (`SA`) produced by the activities. The core activities are: `Brainstorm the evaluation of software techniques and tools`; `Study concepts and principles`; `Replicate an experiment`; and, `Develop an experiment`. These activities were decomposed to atomic tasks. As an example, Figure 4 shows the task swimlane view of the `Develop an Experiment` activity from Figure 3. It contains atomic tasks associated with their respective Formative Assessments (`FA`).

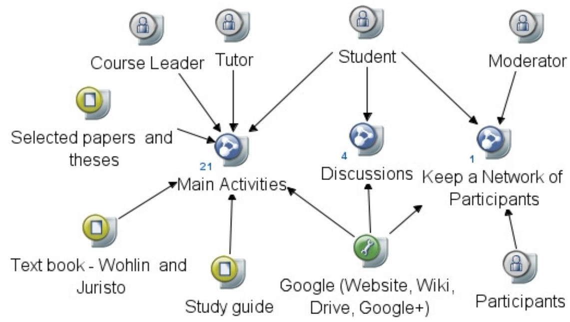

Figure 2: `LOs` view of the ESE course – 1st level.

The `Evaluate & Plan` phase has iteratively produced several versions of the pedagogy profile which were used to adjust and evolve the course design until the course team was satisfied with the distribution of activities. The fact that the course design is explicit and shareable allows designers to discuss and propose improvements, and facilitates the iterative refinement process of collaborative design.

The final balance of activity types was represented in a graph with: 10%-Assimilative; 3%-Finding and handling information; 45%-Communicative; 35%-Productive; 0%-Experiential; 7%-Assessment. There are no Experiential activities because the students were not supposed to participate in didactic experiments; Assessment activities have a low contribution as the course team counted the deliverables under Productive activities; the contribution of Communicative tasks is high as the course was designed to stimulate interaction between the institutions and the work groups.

The course dimension view, as it is a crosscut view, does not add extra information and it is not used here.

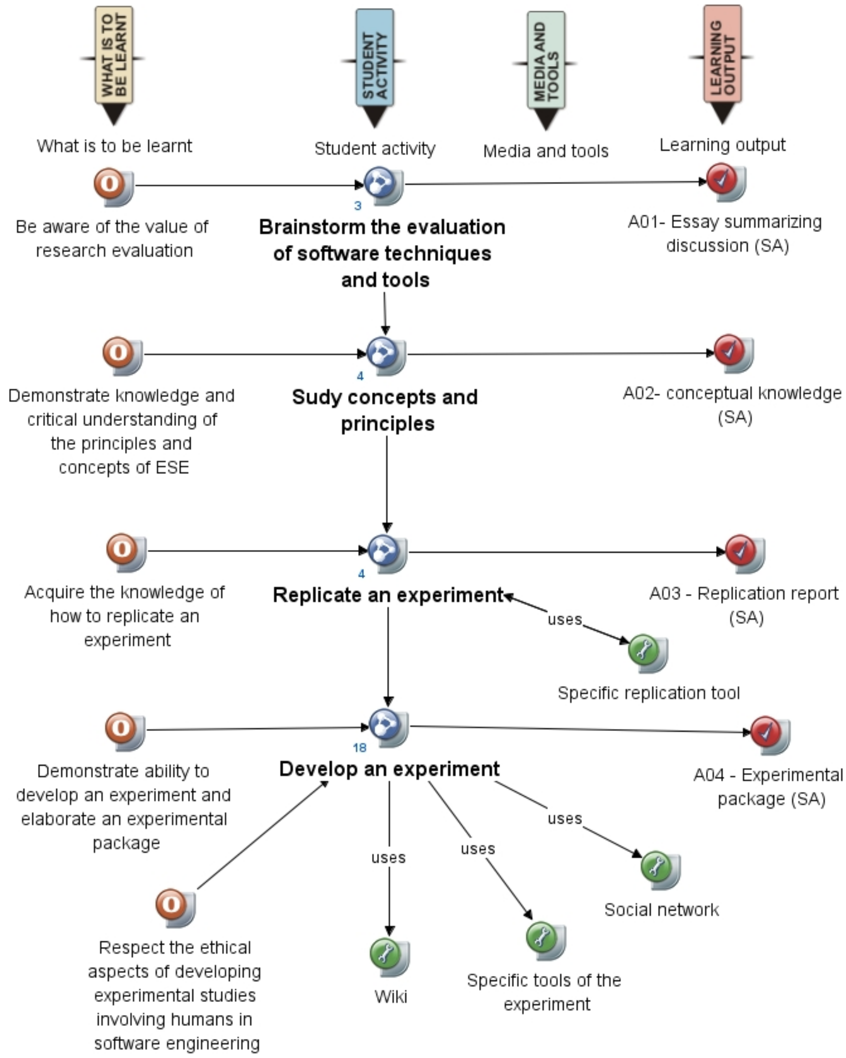

Figure 3: `LOs` view of the ESE course – 2nd level.

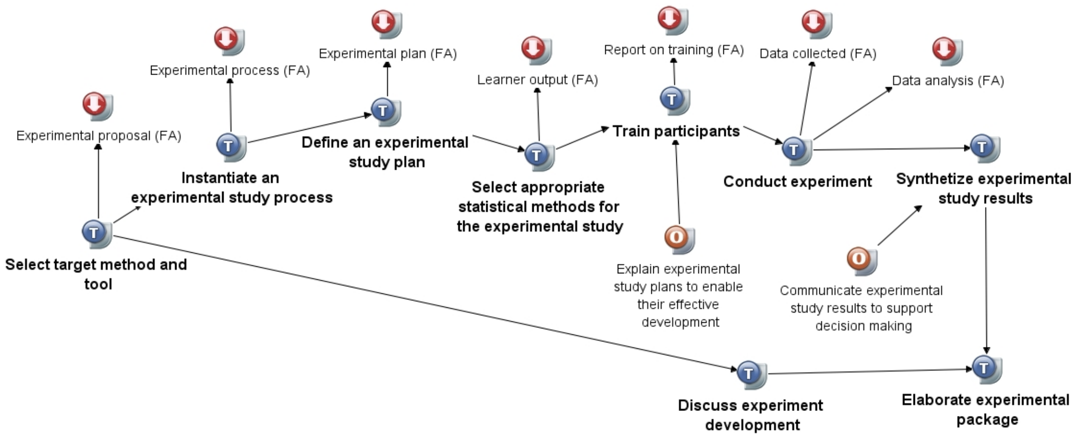

Figure 4: Task swimlane for `Develop an experiment`.

4.2 Course Implementation

The ESE course was implemented within the master's program in Computer Science of the Universidade Estadual de Maringá (DIN/UEM, http://www.din.uem.br) and the Universidade de São Paulo (ICMC/USP, http://www.icmc.usp.br). Delivering a multi-institutional course within research degree programs in Brazil is an innovative initiative which fosters collaboration between institutions that provide these programs. The use of OULDI was important to facilitate and support the collaboration between the institutions both in the planning and in the implementation of the course. The process proposed here, also facilitated this joint development.

Twenty-four students were enrolled in the course, nine from DIN/UEM and fifteen from ICMC/USP. The third and fourth authors were the lecturers in ICMC/USP and DIN/UEM, respectively. All authors participated actively in the course design, following the proposed phases of the OULDI customisation.

The implementation of the course followed the Guidance & Support designed in the course map view (Table 1). There were difficulties in the implementation of Google as the support learning environment. Moodle was chosen, as Google Apps for Education did not have a front end to encapsulate its tools. Also, students and institutions were more familiar with Moodle.

The course was implemented in a blended instruction mode. It was scheduled with the same timetable in both institutions and used the same Moodle site. The support materials were selected collaboratively and made available to students. Classes were intended to be alternated between the institutions and transmitted through video-conference. However, there were technical problems and, in the end, the same material was used but the classes were delivered locally by the lecturers in each institution. Students in each institution teamed up in groups of three. The final presentations of the experiments were successfully transmitted by video-conference and students and lecturers could interact to discuss the projects.

There were no changes to the designed `LOs` and task swimlane (Figures 2, 3 and 4), but one activity, `Replication`, was carried out differently, in each institution, due to individual decision of the local lecturers. At DIN/UEM, each team planned and replicated the same experiment, whereas at ICMC/USP all the students were participants in the replication of one experiment conducted by a researcher with the lecturer's support.

In the end, the `Keep a Network of Participants` was not implemented due to the time constraints of the course and the lack of involvement of the external community. We think this is an activity that should have been planned and developed by the institutions before the course started.

5 DISCUSSION

Results of the ESE course design presented in this paper are discussed from the perspectives of both designers/lecturers and students. One questionnaire was given to students and another to the designers/lecturers; both contained 12 questions regarding course design and implementation, content and structure, didactic and technical resources, learning environment, communication and collaboration issues, among others, as shown in the Appendix.

In summary, designers and lecturers made the following remarks:

- Course design and implementation: They agreed that the OULDI process was interesting and effective both in designing and evolving the course. It provided the course with representations that were used to share ideas within the design team as well as to guide the development of the learning environment for the course. In particular, the course map view helped to think in advance about the course goals and the main structure. Also, the Evaluation & Plan phase was crucial in planning better the course activities. The class schedule was followed accordingly and only small adjustments had to be made, mainly due to technical problems.
- Communication and collaboration: Skype meetings supported communication and collaboration effectively amongst designers/lecturers. However, a more integrated environment both for designing and collaboration is necessary.
- Virtual learning environment: They agreed that Moodle provided a complete set of resources to be used during the course which were easy to use.
- Technical issues: Contrary to what is published that technical resources for distance/blended learning are widely available at low cost, this is still not a reality in many places; both institutions involved in the ESE course had to set up the environments for video-conference. In particular,

DIN/UEM struggled to set up this environment which could only operate satisfactorily by the end of the course.

The students made the following observations:

- Course structure and content: 68% agreed that the content was adequate and well organized in the learning environment.
- Pedagogical resources: the wiki was the most used resource (59%), followed by the calendar (54%), the forum (50%) and email (36%), showing, therefore, a balance in the use of pedagogical resources.
- Communication and collaboration: Despite the results in the usage of pedagogical resources, there were problems regarding the effectiveness of communication and collaboration. At the start, there was some resistance in using the resources available. In particular, it was difficult to engage students in forum discussions. Many activities involving communication and collaboration were proposed as an attempt to encourage them to take part in the discussions. As a result, interesting questions and discussions were gradually arising in the forum, in the wiki, and by email. In the end, 46% of students considered the use of didactic resources effective, 32% were neutral and 22% thought they were of little or no effect.
- Technical resources: As discussed before, the use of technical resources, especially the video-conference environment was the most criticised aspect of the course; 50% of the students evaluated this item as “bad” or “very bad”.
- Motivation, autonomy and self-organization: 82% of the students considered themselves as motivated or highly motivated during the course. Also, 68% of students considered they were autonomous and self-organized to study the theory and perform the suggested practical activities.
- Interaction between students: 95% of students considered the interaction amongst students in the same institution, as “very high”. This is mainly because most students also acted as “participants” of the experiments designed by the other teams. Students organised themselves in this way. However, when considering interaction amongst students of different institutions, 77% of them evaluated it as “very poor”. Only in the final presentations of the experiments, were students of ICMC/USP and DIN/UEM able to interact and discuss the results of their experiments.
- Open comments: Students showed a positive attitude towards the ESE course, especially regarding the pedagogical approach used. The negative aspect pointed out by almost all of them was the duration of the course. Instead of two hours/week, they suggested at least three hours/week for designing and conducting the experiment.

6 CONCLUSIONS AND FURTHER WORK

This paper proposed and applied a customisation of a learning design approach, to a specific domain, that of software engineering. Overall, the learning design approach, and in particular OULDI, proved to be effective to design software engineering courses. In addition, it proved to be efficient in the support of the collaboration between Brazilian institutions in the ESE course design and implementation.

Although there are other learning design approaches in the literature (Koper, 2006; Dalziel, 2012), we are not aware of work being done of their customisation to software engineering. The specificity of the need for professional engagement, the knowledge and experience of design, the familiarity with workflow techniques and tools, and the engagement with the open movement make software engineering education an area that calls for such customisation.

The population of the case study was small, but of a typical size for postgraduate courses. We are aware of the threats to validity regarding the need of its application to a larger and more independent group of designers and students. We intend to evolve the ESE course and the OULDI process, with different groups of designers and students.

This paper carried out an experiment with OULDI and detailed comparison of the same experiment with other methods was out of scope. Further work is needed to comparatively assess and customise other LD methods to SE.

Further work also includes the design of a support environment for the collaborative design of software engineering courses; including mechanisms to access and produce open educational resources.

ACKNOWLEDGEMENTS

We are grateful to CAPES for the funding of Itana Gimenes postdoctoral research at the Open University, UK and the project PROCAD 191/2007.

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APPENDIX

Questionnaire for the lecturers of the ESE module	**Questionnaire for the students of the ESE module**
**All answers to questions have discrete alternatives ranging from 1 (very bad) to five (very good). 1. How do you assess the module's learning outcomes? 2. How do you assess the planning of the module? (Teaching plan, workload, modules' support materials, bibliography, media resources, implementation of the projects, etc.) 3. How do you assess the organisation of the resources available in the module's Virtual Learning Environment (VLE)? 4. How do you assess the communication between students and lecturers? (Consider also communication using the forum, by email, etc.) 5. Which means of communication were used? (Select one answer for each [Forum, Wiki, E-mail, Calendar]: 1 for least used, 4 for most used). 6. How do you assess the effectiveness of the use of resources available in the module's VLE? (Forum, wiki, email and calendar). 7. How do you assess the videoconferencing sessions that took place? 8. How do you assess the students' performance in the assessment? 9. How do you assess the students' independence and self-discipline during the study of this module? 10. How do you assess the communication amongst students in your institution doing this module? 11. How do you assess the communication amongst students of involved institutions (DIN/UEM and ICMC/USP) doing this module? 12. How do you assess the collaboration amongst all lecturers involved in this module? 13. Other comments (add whatever you consider important).	**All answers to questions have discrete alternatives ranging from 1 (very bad) to five (very good) 1. How do you assess the organisation of the resources available in the module's Virtual Learning Environment (VLE)? 2. How do you assess the communication between students and lecturers? (Consider also communication using the forum, by email, etc.) 3. Which means of communication were used? (Select one answer for each [Forum, Wiki, E-mail, Calendar]: 1 for least used, 4 for most used). 4. How do you assess the effectiveness of the use of resources available in the module's VLE? (Forum, wiki, email and calendar) 5. How do you assess the videoconferencing sessions that took place? 6. How do you assess your performance in the assessment? 7. How do you assess your independence and self-discipline during the study of this module? 8. How do you assess your motivation and learning? 9. How do you assess the communication amongst students in your institution doing this module? 10. How do you assess the communication amongst students of the involved institutions (DIN/UEM and ICMC/USP) doing this module? 11. How do you assess the skills and competence of your lecturers? 12. How do you assess the collaboration amongst all lecturers involved in this module? 13. Other comments (add whatever you consider important).

Software Systems Versus Intellectual Property Rights
A Moral and Ethical Challenge for Higher Education in Developing Nations

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Keywords: Computer Systems, Software Systems, Intellectual Property Rights, Higher Education Institutions, Software Piracy.

Abstract: Higher Education (HE) institutions in most countries represent one of the most important users of computer systems. HE institutions need access to fast and reliable computing devices, not only to teach, but also for their day-to-day operations. These systems are not just hardware, but also software systems which are protected by national and international laws. HE institutions may be able to control their employees and their software needs, but it is far more difficult to control students. Their software needs to enforce the respect of intellectual property rights. Students need numerous software packages in order to successfully comply with the academic requirements, whether deliberate or not, some students rely on illegally acquired software systems for their academic projects. This type of behaviours has moral, ethical, legal and societal replications. HE institutions are seen as law-abiding entities, highly respected by their respective communities, applauded by industries, recommended by their governments, and yet their students may be jeopardising that status whether deliberately or by pure ignorance. This study aims at investigating why students engage in using illegal software systems, and why it is difficult to enforce the rule of law when it comes to software licences within HE institutions.

1 INTRODUCTION

This section will introduce the importance of higher education worldwide, the role it plays in developing people and communities, and the challenges HE faces in order to stay competitive and up to date with the latest telecommunication tools. We will also explore the importance of computing systems in HE, the role of software systems, the important duty of protecting intellectual property, and most importantly we will investigate the challenges that most Information Communication Technology (ICT) students faced in staying within the framework of laws, while fulfilling their academic obligations.

HE institutions all over the world have acquired high levels of respect and accountability from their respective governments and other national institutions for their role in creating new knowledge and research in all aspects affecting their respective nations (Rensburg, 2013a). However, learning centres are negatively affected by continuous government budget cuts, lack of external financial assistance and the impact of austerity measures taken to address the respective country's fiscal issues, especially from the ministries of education, or other external donors (Rensburg, 2013b). Some institutions need to enrol as much as possible the highest of number of students, in order to obtain government grants and to ensure a higher financial return. Potential students usually choose a particular stream based on the employment opportunities after graduation, and in the past decade (,) the field of ICT has become the most sought-after field by school leavers who wish to ensure a better future.

In order to produce the best ICT students, the institution needs to be well-equipped with the latest and state-of-the-art ICT tools in addition to having the best academic staff to groom the potential ICT graduates and future industry experts. This means that the best computer laboratories, latest software systems and permanent maintenance personnel need to be in place in order to monitor all student activities.

This study was initially conducted as part of a master's degree research study aiming at exploring the viability and adoption of open source software systems as an alternative in higher education in developing nations. This paper investigates the driving force behind the use of pirated software systems in HE institutions in developing nations.

2 UNDERSTANDING COMPUTER SYSTEMS

A computer system is an electronic device comprising thousands of electronic chips and microchips. Electronic microchips are now also widely incorporated into systems ranging from heavy industrial machineries to miniature handheld computer systems. Generally speaking, a computer system consists of two major components, namely: hardware and software (Meyers, 2003a). The former is regarded as the physical component of the computer system, receiving and executing instructions embedded within the latter (Cashman et al, 2011). Software systems on the other hand, comprise digital algorithms which are sets of instructions that control the hardware components of the computer system (Meyers, 2003b).

Programmers, developers or coders write the coded algorithms and these instructions are translated into a form that only electronically enabled machines can read and execute (Parker & Van Alstyne, 2005). This initial authoring is known as the source code which represents the actual human intelligence instructions. The source code can be accessed, modified, enhanced and innovated by trained persons (Hershey, 2008). The source code can be accessed by the general public. However, this will depend on the licence agreement and its release terms and conditions (Parloff, 2007a). After the compilation, that is the process of transforming human readable code into machine readable code, another authoring is generated, known as the object code. This is a form of authoring that is readable and executable by the machine only (Reijswoud & Mulo, 2004; Toko & Mnkandla, 2011a).

To some degree, the source code is regarded as the actual software system, and users have access to it through purchasing a licensing agreement with its vendor or developers. Regardless of what the licence and agreement stipulates, the users cannot modify it (Parloff, 2007b). Both sets of authoring (source code and object code) constitute the software system the end-user purchases or downloads free of charge from the Internet for whatever purpose (Stallings, 2003).

The vendors, developers and programmers have the freedom to release their product under any licencing agreement of their choice, to define the conditions under which their software systems will be used, the manner in which users will access it and how much users will pay to use it. These factors are protected by Intellectual Property Law (IPR) and usually constitute patent rights (Lau, 2003) thereby preventing other developers, programmers or vendors from copying it. The right to use the software systems is therefore limited in access to the executable component (West & Dedrick, 2005). This means that although the end-users may purchase the software, it does not provide them with the right to modify, compile, innovate or redistribute it (Weber, 2002). This form of release condition is known as ‘proprietary’ had stringent terms and conditions agreement (Steinmueller, 2001), an example will be any Microsoft product . Other vendors may choose to release their software systems without any form of restriction, and all together (source code and object code) provide technically knowledgeable users with the chance of owning, innovating and redistributing the given software systems to meet a particular need (Hill, 2007). Technically this is often referred to as an ‘open source’ and example will be ‘Linux’ product. It is sometimes free of any initial cost and/or further licensing fees, and mostly distributed over the Internet (Parloff, 2007c). Software systems are therefore essential in the smooth running of a computing system without which a computer system will only be a piece of hardware with no utility.

3 INTELLECTUAL PROPERTY RIGHT

An intellectual property right is a law that protects any outcome of intellectual effort; it can be enforced locally or internationally in a court of law; it can be granted to a person, group, company or entity, and enables them an exclusive right to exploit for their own benefit any positive benefit without having to keep a watchful eye on competitors who may simply copy their invention, creation or innovation (Karakaya and Uluturk, 2010). The use of such laws limits any form of imitation or duplication by conferring monopoly power to the holder. In most cases, it may comprise full or sectional rights, and can include, but is not limited to copyright, patents, trademarks, geography indication, related rights, author rights, moral rights or trade secrets (WIPO, 2004). The reasoning behind these initiatives is to motivate people to generate new ideas, and to protect them and their creations and subsequently motivate others to compete on an equal footing. For example, a copyright gives the exclusive right to reproduce, distribute, perform, display, or license a particular work of the inventor if required, and thus constitutes a licensed derivative of his work (Olsson, 1993). Generally speaking, the enforcement and protection of intellectual property rights at international level has always been a complex issue, and depends on each country and most importantly on the type of political climate in each nation which may have an impact on the extent to which these laws are enforced.

Software systems are known as the creation of the human mind, and in most cases they are developed by individuals or companies with important patent rights. The majority of software systems these days are proprietary and represent a foreign product in most developing nations where they are most of the time formally protected by local laws, whereby the use and reproduction need to be authorised by the licensor (Idris, 2003).

4 SOFTWARE LICENSING

Regardless of how a person acquires a proprietary software system and some open source systems, for example from the internet or via CD, DVD or USB, during the installation process there will be a stream of different screens to go through before the actual software system is loaded onto the machine, and one of these screens will deal with the terms and conditions. These will stipulate the conditions under which the product that is about to be installed can be used. It is assumed that if the user cannot comply with these conditions, the software shall not be installed. Ironically, even when the software system which is about to be installed has been acquired illegally, the same screen must be validated to move to the next screen, and this brings up the question of morality as the end-user is the only one to judge whether or not to continue with the process when realising that the product may have been illegally acquired (Hinduja and Sameer, 2003).

Software licensing is seen as a legal instrument governing the use and distribution of a software system, although today much of the distribution of software systems is made over the Internet which offers greater control. However, many, due to lack of Internet connectivity in most developing nations, are still distributed using hard material hence, the high rate of illegal redistribution of software systems in many homes, businesses and HE institutions (Depken II et al, 2004).

The terms and conditions of these software systems do not only restrict illegal copying, but also restrict loading the product onto various computers without the authorization from the vendor. The question is thus how can one make sure that a software licence that was legally awarded to a single computer is indeed installed on a single computer only? It is at this point that the issue of morality and ethics arises, and there are many who believe that many illegally installed software systems are originally acquired legally, and become illegal only when used beyond the restricted number of computing devices (Higgins et al., 2005). Software licensing in general contains various provisions which enable legal and structural liability between both parties (the licensee and licensor). Thus, even when the software has been acquired legally, the buyer does not have the right to modify, enhance, or innovate the source code of the product. And whether one is dealing with open source or proprietary software systems, there are always conditions that the end-users have to respect, and monetary values are not the only access conditions (Husted, 2000).

5 CAUSES OF SOFTWARE SYSTEM PIRACY IN HE INSTITUTION

According to Musa Karakaya and Bulent Uluturk (2010), the “lack of information, poor administration and control of software installed on campus computer systems, poor moral standards, absence of academic ethics, poor commitment from academic staff about the respect of intellectual property, high price of proprietary software systems, and low level of understanding of country laws are the driving forces behind the high rate of piracy” in HE institutions. This neatly points to the fact that behind the software piracy phenomenon in various HE institutions across the many developing nations students are under immense pressure to complete academic projects using advanced and the latest software systems, very often, mostly at their own pace and with little supervision. Moreover, the price of such software systems is often beyond their reach, and outdated systems are discarded without further explanation. Indeed, many students are so poor they require financial help to fund their studies (Rensburg, 2013c). Moreover, many ICT streams do not offer legal subjects or modules to help students understand the repercussions of their actions or the legal implications of using pirated software. In many cases academic staff at the universities are not equipped enough to easily trace project development with non-legal material; and most importantly various HE institutions do not have a clear policy regarding software piracy pertaining to students use even though they may have an acceptable policy for their staff.

6 ICT STUDENT AND USE OF ILLEGAL SOFTWARE SYSTEMS

In South Africa, the National Qualifications Framework (NQF) is used to standardize university degrees and national diplomas, all of which are three-year qualifications with regard to Application Software Development, IT Management, ICT Management or Systems Support as major subjects. Every student registered for an NQF 4 is expected to submit a complete application that has been developed as part of their final project upon which the final evaluation is based (Faculty of Management Regulations, undergraduate and postgraduate, University of Johannesburg, 2012). For many, this moment remains the most memorable academic event with the presentation of their final application to the general public and ICT industry experts, the latter forming part of the jury.

Students facing this learning experience have to come up with a topic, an idea or a problem and develop a software application system to address or solve it. Thus a system needs to be generated by the compiler, or written or developed by someone else. Generally the project must be a student's original solution; they need to select the software system platform they wish to use and most importantly finance it which many can't afford. As a result, many, even in reputable universities, resort to using an illegal software system in order to complete their qualification. One of the aspects that stood out at the 2010 student exhibition was that most application systems had been developed using proprietary software products. It is important to note that the students were not bound to a particular computer system platform or expected to select a particular platform. Rather they were free to make use of whatever application system (e.g. compiler) or platform they found suitable. This was the case not only for their "front end" GUI, but also for their "back end" (database systems) or operating systems, thus meeting the objectives of South Africa's national plan for higher education which is: "To produce graduates with the skills and competencies required to participate in the modern world in the 21st century" (Damoense, 2005a). When examining the final projects of the students, the part that first appears is the user interface front end. Nearly all the students chose applications related to Microsoft Visual Studio such as Visual Basic Dot Net (VB.NET), ASP.NET or C#, all of which are PS and Microsoft products. For the back end most decided on an SQL server, and again a PS, these being solid, reliable and robust.

7 OVERVIEW OF THE COST OF SOFTWARE SYSTEMS

The cost of the software licensing fees in the developing world is reasonable compared to other imported ICT materials (Gush et al, 2004). Mostly evaluated in foreign currency (US dollars), it is estimated that licensing fees cost the Australian government around $430 million annually (Scott, 2004). The Republic of South Africa spends 65% of its annual ICT budget on licensing-related costs (NACI, 2004). Worldwide licensing amounted to $35 billion in 1998 and $171 billion in 2000 (Evans, 2004).

For a developing country software licence fees can become a major hurdle for ICT and overall national development (Bruggink, 2003) with most of the vendors (software companies) operating from abroad or using subsidiary local entities to reach their end-users and provide technical support services (when necessary). As a direct result, large amounts of foreign currencies leave the country's shores annually (Ghost, 2003a). In South Africa the situation is similar to the rest of the developing world with the estimated software licence cost totalling around $2,620 per GDP/capita (Ghost, 2003b). This untenable situation has resulted in a high volume of pirated software being used in many South African homes, schools, HE institutions and small businesses (Toko & Mnkandla, 2011b). It is estimated that over 38% of the total software used in South Africa is pirated (Ghost, 2003c).

8 EXAMPLE OF SYSTEMS COST IN HE INSTITUTIONS

In 2007 the University of Johannesburg (UJ) developed a separate business entity to control and manage its computer laboratories with the aim of making them more effective and efficient. The university is spread across four campuses around the city of Johannesburg, namely Soweto, Doornfontein and two campuses in Auckland Park: Bunting Road and Kingsway, each with its own computer laboratories. It is estimated that the software licensing fee for the Soweto campus alone is approximately \$56 980, for Kingsway approximately \$ 152 72, for Bunting Road approximately \$248 98 and for Doornfontein approximately \$82 55. This amounts to a total budget of approximately \$1 065 54 or \$152 220 US for the year 2008. At this stage these figures relate only to licensing fees for software such as *Ghost* and *DEEP FREEZE*, and do not include operating systems and other office automation systems. Software-related licence fees regarding staff are not included. If one had to expand this to office automation software such as MS Office, OS, antivirus, antispyware and Internet connectivity software, the cost of licensing would run into tens of millions of rand annually.

9 THE IMPORTANCE OF SOFTWARE SYSTEMS IN HE INSTITUTIONS

H.E institutions develop their internal infrastructures to meet their technological needs and to keep pace with their competitors, world trends, labour constraints, internal goals and the modern world (Damoense, 2005). According to Adams (2003, p18): “With few exceptions, universities have been unable to develop and implement programs, such as advanced research in networking, computer science, community applications, and programs that promote technology-savvy intellectual capital. Economic factors ranging from the lack of capacity to pay for costly infrastructure to sustaining computer networks introduced through donor funding weighed on universities as their budgets continued to get slashed.”-

ICT research and development have for years been an integral part of H.E institutions worldwide, and most importantly, these institutions have participated in many successful advanced ICT projects that have had a huge positive impact on the ICT industry and society in general (Câmara & Fonseca, 2005). The science and technology innovation that the world is currently experiencing is mainly driven by academic researchers upon whom industry researchers rely, not only to get accreditation for their personal research findings but also to validate them, and obtain technical support and acknowledgement (Fresquez & Frias, 2006). Academics thus play an important role in creating awareness of intellectual property rights. Developing a community of law-abiding developers is thus seen as crucial for any respectable nation (Wooi, 2004). A particular example is the role scholars and academics have played in developing the UNIX operating system, one of the most reliable, stable, secure and free pieces of OS that has led to further software development around the world (Parloff, 2007d). The ICT academic world is also regarded as the human resource development ground for the ICT industry, helping to make H.E institutions a breeding ground for ICT industry professionals. Furthermore, the level of education or qualification is the most fundamental and reliable evaluation instrument used to determine the suitability of any candidate entering the sector (Damoense, 2005c). The qualification of the potential entrant is evaluated against university standards and monitored by the Department of Higher Education.

Up to now we have explored, explained and elaborated on various aspects pertaining to the role of software licensing, and motivations that drive the ever increasing number of pirated software systems in many H.E institutions - mostly in developing nations. Very often these H.E institutions from developing nations compete with first-world institutions, these ICT products are priced with set and standard consumers in mind. Thus, as a result of internal financial problems of many developing countries, illegal products are often used in some H.E institutions even though such actions are seen as immoral, unethical and unacceptable in all cultures. Nevertheless some H.E institutions are not only the repositories of knowledge, but some are indirectly promoting “white collar” criminal activities when “forcing” students to keep up to date with the latest technology which they can only afford by obtaining pirated software if they wish to succeed in their academic studies.

10 METHODOLOGY

The research study was conducted over a period of two years as part of a larger research project known as ‘The role of open source software in higher education institutions’ which is available online under the university of Johannesburg website. This type of research is generally classified as research project; it enables the researcher to develop solid research literacy at a time when reliable academic data is non-existent in many developing nations. The method employed was exploratory followed by explanatory built-up research. For this particular research project, a quasi-experimental research design was used due to its nature and the aim of the project. The most important motivation for these choices was the ability to use a survey questionnaire over the Internet which could easily be distributed to people in the most remote locations in South Africa. The project was primarily conducted in the Republic of South Africa, although the outcome can be easily replicated in other developing nations around the globe.

A questionnaire was sent to various H.E institutions around the country and uploaded onto the Internet. The main sources of data were students, academics and ICT professionals operating in various H.E institutions around the country. The Internet thus enabled respondents to access the questionnaire wherever they were. Participants were randomly selected without targeting a specific group. The researcher drew the sample population from all corners and sectors of H.E institutions in the country, i.e. from people with both ICT and academic backgrounds. The stratified sampling method was used to obtain data for analysis. This selected approach is based on probability sampling which enables each participant within the target population an equal chance of being selected. The primary target was to reach at least 200 respondents from all sectors, namely ICT students, academics, professionals. Each question was designed to address a specific outcome which could help understand the problem at hand, and we received nearly 600 responses. The aim of the research project was to examine how students understood intellectual property rights in terms of software licensing issues.

11 FINDINGS

The survey questionnaire was completed online. Although the research questions addressed many software-related issues such as open source software systems versus proprietary systems, this paper will only deal with the question related to the understanding of intellectual property rights of software systems within H.E systems.

Question 1

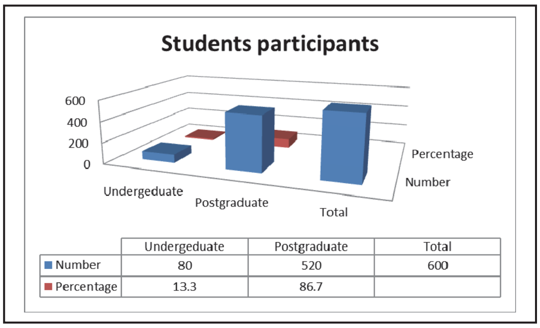


Figure 1: Student level of study.

Question: Please indicate if you are an undergraduate or postgraduate student.

Analysis: This question was primarily aimed at getting to know the students, to know whether they were undergraduates or postgraduates. It was assumed that postgraduate students are better equipped to understand the implications of using illegal systems, and those undergraduates still required more time to be informed about the dangers of using unlicensed products. We noted a large number of undergraduate students as compared to postgraduates who participated in this study. This was expected, because in most cases, as student progress academically, and graduate, they look for jobs and put any future studies on hold.

Question 2

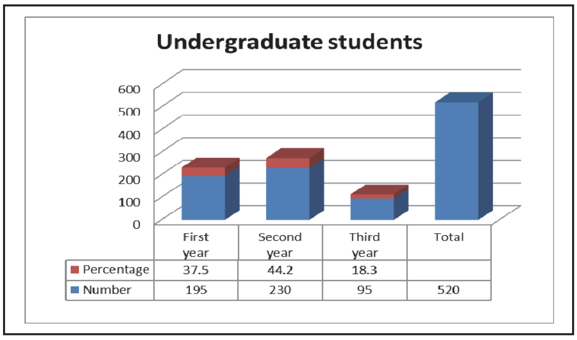


Figure 2: Sub-level within undergraduate student.

Question: If you are an undergraduate student, please indicate you current progress.

Analysis: This question is aimed at narrowing the focus to a particular sub-group. It was expected that undergraduate students would form the biggest group because as they progress through their academic studies, many students drop out of the system, thus resulting in a smaller pool of postgraduate students. Moreover, it is assumed that first-time students are the most ignorant when it comes to various aspects relating to software licensing and intellectual property. In addition, in many institutions, third-year students are required to submit a final year project where they have to develop their own software systems. It was assumed that this final project would put pressure on students so much so that they would tend to use pirated software given the high standards required of them. However, the results showed that second-year students were the most common users of pirated software, followed by first-year students, and then by third-year students. This pattern may be explained by the fact that many students drop out during the course of their academic studies. The reasons for dropping out are many, including a lack of financial means to pay for further studies.

Question 3

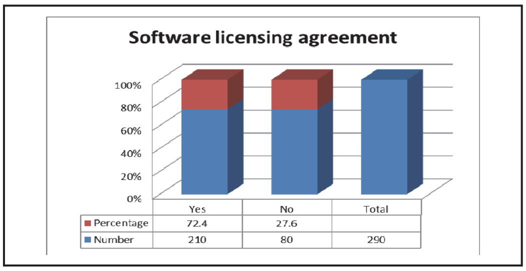


Figure 3: Software license agreement.

Question: Does the institution where you are enrolled provide you with software?

Analysis: This question was aimed at determining whether or not certain institutions that were aware of the availability of software systems for their students made these available free of charge. Providing software systems to students doing ICT-related courses sometimes falls under the umbrella of "corporate responsibility". By engaging in such actions, organizations help alleviate the financial burden on students who, as a result, do not have to resort to using illegal software systems for their academic projects. In response to this question, it was found that nearly 200 students said that they received software systems from their respective institutions. This might be due to the fact that the problem is so common that the only way to cope with the demand of software systems is for the H.E institutions to provide the software themselves in order to limit software piracy.

Question 4

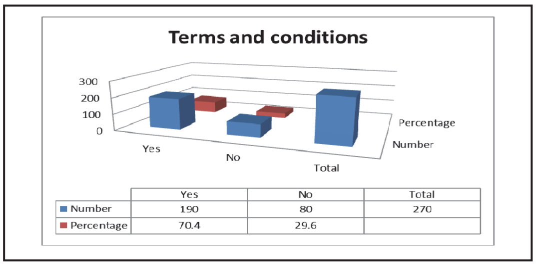


Figure 4: Software terms and conditions.

Question: Are you aware of the terms and conditions of using software systems?

Analysis: This question was primarily intended to assess whether or not students actually read the terms and conditions of the software system installed on their computer system. Very often the lack of understanding or ignorance may lead to non-compliance with the country's rules and regulations. Before any law can be enforced, it is important to assess whether the law is well explained and understood. The answers to this question suggest that the majority do read the system's terms and conditions. This can be explained by the fact that many are forced to read these terms and conditions in order to proceed with the installation. In fact the end-user needs to validate the condition window before proceeding further.

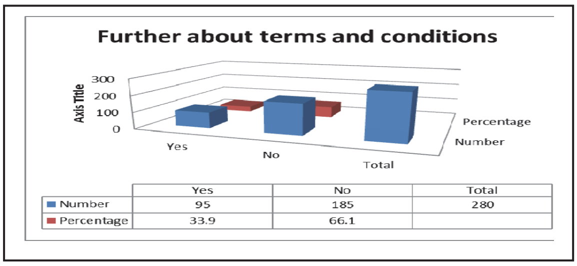


Figure 5: Terms and conditions understanding.

Question 5

Question: Do you understand the terms and conditions of your software system?

Analysis: This question was meant to examine whether after reading the terms and conditions, which the majority claimed to have read, they actually understood what they had read. Moreover, since most software systems need a positive validation of the terms and conditions in order for the user to be able to move to the next step of the installation, does this contribute in any way to the lack of understanding of the legal conditions? In the previous question, most indicated that they did indeed read the terms and conditions, and thus the question needs to be asked whether they actually understand what they have read. The answers to this question indicate that the majority do not understand the meaning and importance of such texts. This result supports the previous assumption that many merely scroll through the terms and conditions in order to be able to install the system.

Question 6

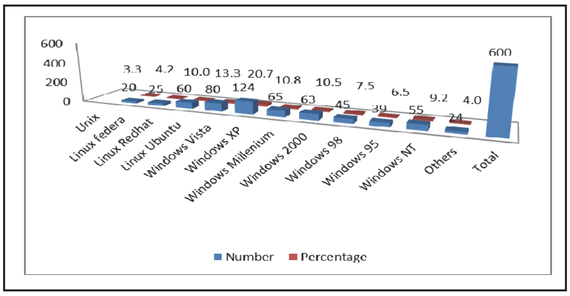
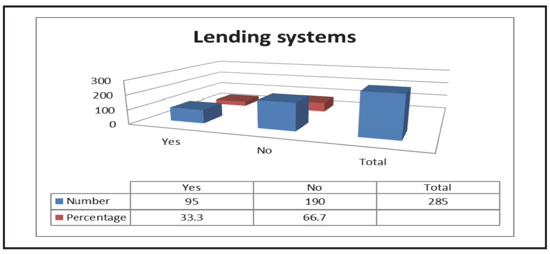


Figure 6: Types of operating system on private PCs.

Question: What types of operating systems are installed on your private computer?

Analysis: This question seeks to ascertain the number and types of operating systems installed on students' computer systems in order to understand whether there is a match with their institutions' systems as far as the operating system only is concerned. Knowing the types of operating system installed on students' computers will help to understand what sort of software needs they may have. This question thus indicates that XP is by far the most commonly used operating system which is a proprietary system and therefore requires licensing. Moreover, because of the type of platforms they are running, there will be some specific types of applications that can be supported; hence there should be a better understanding of the intellectual property rights.

Question 7



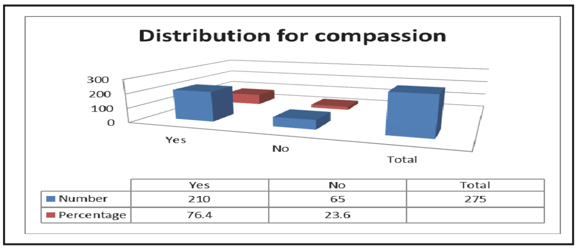
	Yes	No	Total
Number	95	190	285
Percentage	33.3	66.7	

Figure 7: Lending software systems.

Question 7: Have you ever asked a friend, lecturer or ICT department to make you a copy of software (or installed it on your private computer system) you urgently needed for a school project and because you could not afford to legally acquire a copy of your own?

Analysis: This question brings up the fundamental issue of software piracy among students, especially from previously disadvantaged students. The cost of most software systems are beyond the reach of such students and this ultimately results in many of them using illegal systems. It is to be expected that when facing the issue of obtaining software that is out of reach as a result of financial constraints, students will ask help from their friends in order to complete a project. More than half of the participants admitted asking for a software copy from friends.

Question 8



	Yes	No	Total
Number	210	65	275
Percentage	76.4	23.6	

Figure 8: Software system distribution for compassion.

Question: During a class project you managed to legally obtain a copy of the software system needed for the project; you then realise that many of your classmates can't afford to access it, can you share the software system with them, install it on their system, or simply make duplicate copies so that they have their own copy?

Analysis: The answers to this question show that in many instances end-users of intellectual property are not aware of the crime they are committing by illegally making copies of the software systems they legally purchased. Moreover, in many communities, sharing with the less fortunate is embedded in their culture, and depriving others from what one abundantly has is seen as immoral. This view also impacts on the sharing of software systems, and many software system vendors will limit the usage of their product to a certain number of computers, end-users, or put a limit on the time during which it can be used. The answers to this question indicate that the majority of students are willing to make copies of software systems in order to help fellow students. The question thus arises whether they actually are aware that by doing this, they are engaging in an illegal activity. This indicates how very often legally acquired software systems become illegal as people make copies not knowing that their legal software system was meant to be used on one computer system only.

Question 9

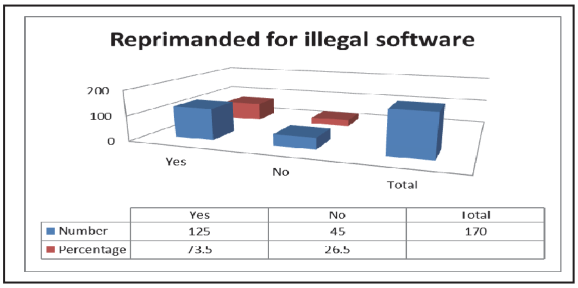


Figure 9: Reprimanded for using illegal software.

Question: Have you ever been reprimanded for using an illegal software system on your campus computer system?

Analysis: Many H.E institutions are well aware of the software licensing issue, and more specifically of the use of pirated software on their computer systems or on students' final year projects, which are used for evaluation. In many cases, there have been reprimands and students have been asked not to repeat this offence. This is an important step towards understanding the importance of intellectual property rights in H.E. It was found that more than half admitted to having been reprimanded after illegally making copies of a software system. This can be seen as a way of enforcing the rule of law to some degree; it also indicates the extent to which the problem seems to have escalated.

12 CONCLUSION

The literature shows the extent to which H.E institutions are facing the impact of software licensing costs, how this affects their operational needs, and how more financial assistance is needed to help alleviate this non-academic burden. Most countries in developing nations are capitalist economies, practicing a free market economy, which simply means that whenever someone invents, re-invents, innovates or discovers something new after investing substantial financial amounts into the project, they expect a return on investment. Thus, before anyone can gain access to the product, permission will have to be granted for the use of the product, otherwise the use of the product is deemed unlawful and such infringements of the law will result into legal action. H.E institutions are seen as a mirror of society, are usually well respected, are known to have a high moral standing, and therefore should not be involved in any way in unlawful practices. This applies to both their staff and their students. Nonetheless, some of these unlawful activities are carried out without the knowledge or consent of the institution. Moreover, some of the students engaging with such activities are not well informed regarding the repercussions of their actions (see Questions 3, 4 and 5). They seem to be ignorant of the fact that making a copy of a software system without prior approval of the owner constitutes a crime. This paper has shown that many students are using illegally obtained proprietary software systems on their private computers (see Figure 6), and yet they ignore the conditions under which such software may be used. Figure 7 and Figure 9 indicate that the majority of students who participated in this research have at least been reprimanded for making illegal copies of software systems. It is important to note that the phenomenon of software piracy may have serious repercussions and can tarnish the image of any institution found supporting the illegal use of intellectual material such as software systems. Ideally, legal software systems should be distributed to all registered students free of charge, but budget issues may limit this ambition. Moreover, the high cost of Internet connectivity in most developing nations compels developers and vendors to distribute their products via CDs and DVDs, which are more likely to be copied. The theft of intellectual property is not acceptable in any nation, no matter how poor, yet it is understandable why end-users like disadvantaged students are tempted to obtain pirate copies. Software piracy can take many forms, and it should be noted that many students are not even aware that they are acting illegally, for instance when obtaining copies from friends. The only thing that may stop or prevent them from engaging in such illegal activities would be their moral and ethical values.

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A Faculty/Staff/Student Team for Collaboration in Developing Mobile Applications in the Software Engineering Course

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Keywords: Collaborative Learning, Project-based Learning, Immersive Learning, Mobile Applications.

Abstract: A faculty/staff/student team was used as a collaboration model to develop, maintain, and improve mobile applications built for use by students on the campus of California State University, San Bernardino. The team was developed in the software engineering class where the projects are mobile applications requested by real clients in the campus. After the class is over, the students continue the development through independent studies and senior projects. During this time, the students work with a team of student interns and staff from the Administrative Computing Services, Information Technology Division of the campus until the mobile applications are published in both Google Play and Apple App Store. Using the CSUSB Student Opinion of Teaching Effectiveness (SOTE) surveys of the software engineering classes of 2009 – 2013, we found that students learn tremendously through hands-on experience and actual interactions with real clients, and also found that the principles and concepts of software engineering are learned better.

1 INTRODUCTION

A unique partnership was formed. The CSUSB faculty/staff/student team developed and maintained mobile app products for the campus for use by students. Currently these mobile app products are: CSUSB Mobile, Tour CSUSB, CSUSB RecSports, and CSUSB Library. CSUSB Mobile provides information and service to students for accessing class schedules, financial status, grades, payments, Blackboard, etc.; Tour CSUSB provides a virtual tour of the campus, which is used for recruiting students; CSUSB RecSports provides schedules and information regarding physical fitness and training at the fitness center; and CSUSB Library provides information and service to students using the libraries at both San Bernardino and Palm Desert campuses. Figure 1 shows the Web site https://mobileapps.csusb.edu. The mobile apps run on both Android and iOS platforms. The mobile apps were built by students for students.

The CSUSB faculty/staff/student team consists of faculty and students from the School of Computer Science & Engineering, College of Natural Sciences, and the staff and student interns at the Administrative Computing Services, Information Technology (ACS/IT) division.

There were two news releases regarding the publication and availability of "CSUSB Mobile" in our campus: "University adds more mobile apps to help make navigating CSUSB easier" which appeared on 28 Oct 2011 http://news.csusb.edu/2011/10/university-adds-more-mobile-apps-to-help-make-navigating-csusb-easier/ and "CSUSB mobile app updated with improved performance, graphics" which appeared on 31 Oct 2012 http://news.csusb.edu/?p=18592. The first article is announcing the availability of the mobile app services on campus while the second article is about re-engineering the mobile app to improve graphics, significantly improve performance, and minimize bandwidth usage. The second version uses a hybrid approach, where approximately 90 percent of the content is installed on the device and the rest resides on a secured server.

The goals of the faculty/staff/student team at CSUSB are two-fold:

-- To create a model in the software engineering course so that students would learn the principles and practices of software development through the mobile app projects in class.

-- To establish in the ACS/IT division the capability to support and manage the production of mobile app projects from either clients on campus or external to the campus.

Figure1: CSUSB Mobile Applications.

To achieve the goals above, the following are the objectives:

-- The students should know how to elicit user requirements.

-- The students should know how to write the software requirements specification (SRS) document.

-- The students should know how to write the software project management plan (SPMP) and the corresponding software quality assurance plan (SQAP).

-- The students should be able to develop and manage repositories and development server environments in support of software development.

-- The students should know the different mobile technologies and programming languages used in the development of mobile applications.

-- ACS/IT staff personnel provide support to a team of student interns who are working on existing and currently developing mobile app projects.

-- ACS/IT provide financial support to student interns who are working on existing and currently developing mobile application projects.

-- ACS/IT upper management provide management and support to the faculty/staff/student team for mobile application projects.

The faculty/staff/student team supports project-based learning (PBL), which is described by (Markham, 2011) as integrating learning and knowing. Because of the ubiquity of mobile devices and the seemingly endless new applications that can be developed, students become motivated and eager to complete the project.

2 SOFTWARE ENGINEERING COURSE

The software engineering course is an upper-division requirement for majors in the School of Computer Science & Engineering, CSUSB. The course is run as a mock software engineering (Concepcion, 2005) where the class is organized into management teams and programming teams and each student plays a role in the software process as: project managers, team leads, software engineers, quality assurance, system administrators and technical writers. One of the major software project used in the class is AlgorithmA (Algorithm Animation) project (Concepcion, 1998, Concepcion, 1999, Concepcion, 2000, Concepcion, 2005, James, 2008). This software project has been maintained for over 20 years!

In Winter 2011, some of the staff at the Administrative Computing Services requested to include in the software projects, a mobile application project, in the software engineering class. which was deemed important because ACS was thinking of developing mobile apps for use by students in campus. So one of the software projects to be done in that quarter term was a mobile app project. The software project will be used as a prototype from which we developed the CSUSB Mobile app. From this prototype, the CSUSB Mobile was created. The following year, Winter 2012, all software projects were mobile app products. Three of them were published: CSUSB Library, CSUSB RecSports, and Tour CSUSB. This winter 2013, we prototyped five more mobile app products: Sodexo CSUSB Dining, Coyote Radio, RAFFMA Museum, Student Advising, and Slidewinder, our first iOS mobile game.

2.1 Software Requirements Specification

The software life-cycle starts with a document called Software Requirements Specification (SRS), which contain the software requirements that the client needs. The elicitation process is obtained through interview, meetings, and e-mail communications between the client and the development team. After about 2 weeks of the elicitation process, the team writes the SRS following the IEEE Std. 830-1998 format for SRS. The SRS is completed when the client approves the document. All students are required to write the SRS and then the best written SRS is selected to be the SRS for the specific mobile app product.

2.2 Software Project Management Plan

While the SRS is being finalized and completed, the management team writes the Software Project Management Plan (SPMP). This document contains the organization of the development team, the resources, the milestones schedule, management process, software process, and the risk management. Following the IEEE Std 1058-1998 format for SPMP, the team submits this document to the instructor for approval. The SPMP becomes the definition of the software process that the development team will follow to implement the mobile app product. Figure 2 shows the project organization of the software engineering class. And Figure 3 shows the list of clients for the project organization shown in Figure 2.

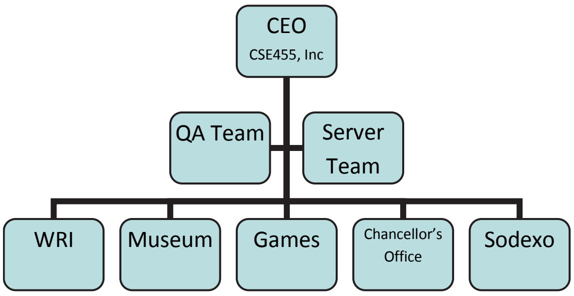

Figure 2: Project Organization for software engineering.

Besides the management team and the development team, there are two support teams: the server team and the quality assurance team. The server team configures the development and production servers. They also set-up the repositories where all the source code and documentation will be stored. The QA team is in-charge of software reviews and testing of source code.

Following the Agile Software Methodology, we had two iterations of the mobile app product in the quarter term. The first iteration takes about 4 weeks and the second iteration takes the last three weeks of the term.

The document also includes risk management. This is the identification of the software product risks and the software product risks. The management team must identify these risks and when it occurs they should have a plan on how to handle the risk.

Table 1: List of clients for project organization in Figure 2.

Client (CSE 455 Mon / Wed)
Water Resource Institute – Tree/plant identification for 2nd grade students (Boykin Witherspoon) **Museum** – Virtual tour of Egyptian collection (Paige Taylor). **Games** – SlideWinder (Jack Price). **Chancellor's Office** – How to get to college gamification (Robin Wade). **Sodexo** – Campus dining/Cafeteria, catering (Emily Orquiza).

To promote motivation among the student, Outstanding Software Engineer awards are given to each development team including the support teams. Each team selects their own outstanding software engineer using the criteria: significance of the contribution the product and involvement in improving the programming skills of the individual members of the team.

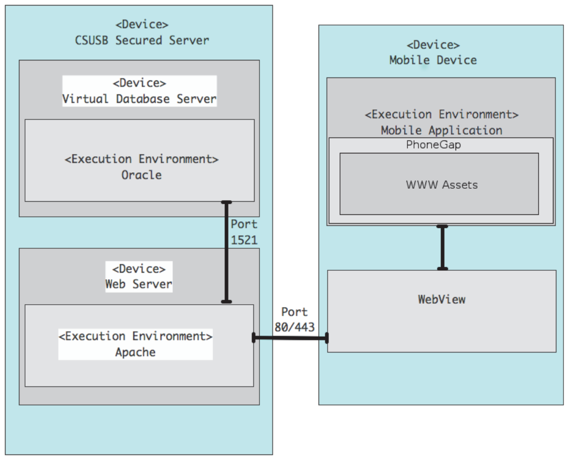

Figure 3: Mobile app development diagram.

2.3 Software Design

Several team members undertake this phase of the software life-cycle, the software design. This phase consists of two parts: the architecture and the detailed design. The Unified Modeling Language (UML) is used as the design notation for this phase. The architecture begins from the deployment diagram found in the SRS. This diagram shows the major hardware and software components of the system that will be needed to run the mobile application. The hardware components usually consists of the secured server and mobile devices while the software components usually consists of the PhoneGap application, user-interface, and the database system. The detailed design consists of the detailed class diagrams or component diagrams of the software components of the architecture. The detailed design could also consist of important algorithms that are used in solving problems in the implementation. Shown in Figure 4 is the UML deployment diagram of a typical mobile app product.

2.4 Implementation and Coding

The most common implementation and coding used is Extreme Programming (XP). This method allows the production of code through two steps: coding and testing. The team of two students, given the requirements of what this software component will do, will code and test their increments of code until the requirements are fulfilled. Once the different components are completed and tested, they are integrated into larger and larger components. Integration testing are done to ensure they work and free of faults/bugs. Finally, system testing is done to ensure that the mobile app works with other systems, such as database systems and Web sites.

Some students used the SCRUM method, where sprints of important features are implemented in a period of one week. The features are chosen from a priority list which was specified by the client. Other students used the conventional Waterfall model and had mini-Waterfall model for each iteration of the product. All source code, design and documents are stored in the repository set up by the server team.

2.5 Software Reviews and Testing

The class follows the non-executable testing and executable testing methods. In the non-executable testing, the class reviews the SRS through a series of use case diagrams and sequence diagrams where a scenario of how the software will be used is applied to determine any inconsistent or ambiguous requirements are present. The student then use the same techniques above for SRS in reviewing the software design. All of these testing methods and techniques are found in the document Software Quality Assurance Plan (SQAP). It is written using the IEEE Std. 730-1998 format.

The quality assurance team performs the alpha testing of the mobile app product. Here the testing is done if all the functions listed in the SRS are working properly. If a fault/bug is found, the mobile app is given back to the development team to fix the fault/bug. This process is repeated until no more fault/bug is found. The development team is not credited the completion of this phase of the software-cycle, until the development team pass the alpha testing set by the QA team. The mobile app product is then given to the client for the final testing, the beta testing. The client and all the users in their office are given a copy of the mobile app product and tested for actual use in their environments. Any fault/bug are reported back to the development team and fixed. This process is repeated until no more faults/bugs are reported.

2.6 Demo and Presentation

The demo and presentation were done on the finals day of the quarter term. This is done at the end of the second iteration of the mobile application following the iterative software process as defined in the SPMP. All the clients of the mobile apps, invited representatives of the local software companies, and guests of the students are invited to the demo and presentation.

The demo and presentation is in a form of an exhibition/booth style where each team sets a location in the labs and there they present and demo their mobile app product to any visitor of their "booth." They either have a mobile device or an emulator running to show the product. They may also have powerpoint presentation in their "booth." The students remove their "software engineering hat" and put on a "sales person hat" selling their products to the visitors.

Local software companies that have visited us in the past are: Esri, Optivus Proton Therapy, iMedRIS, Epic Management, Kelly Space, and Surado Solutions. We also have the announcement of the Most Outstanding Management Team awarded on the day of the demo and presentation.

3 EVALUATION RESULTS

PBL shifts the emphasis from the core curriculum of software engineering to the application of the principles and concepts to actual projects. (Markham 2011) also said that the student's drive, passion, creativity, empathy, and resilience cannot be taught but are exhibited by the student when doing the project. To measure the effectiveness of the PBL techniques through the faculty/staff/student team, we used the CSUSB faculty teaching evaluation survey, Student Opinion of Teaching Effectiveness (SOTE).

3.1 Student Opinion of Teaching Effectiveness

SOTE is used to evaluate the teaching effectiveness of faculty at CSUSB and is used to determine the effectiveness of PBL in the software engineering course. It has 5 questions:

Q1: Rate your interest in the subject matter of this course before you took the class.

Q2: How many class sessions did you attend?

Q3: Why did you take this course?

Q4: How would you rate the overall quality of instruction in the course?
Q5: How would you rate your professor's specific contributions to your learning in this course?

The last two questions (Q4 and Q5) were used to rate the student's evaluation of the course and the instructor.

3.2 Results

The last two questions are evaluated as follows: lowest score of 1 for unsatisfactory, 2 for poor, 3 for fair, 4 for good, 5 for very good, and a highest score of 6 for excellent. For each question, the total number of students, the average score, and the median score are printed. The mobile apps project started in 2011 and has been used as the software project in software engineering since then. See Table 2 for the comparison of results of the SOTE from 2009 – 2013.

Table 2: Results of SOTE

Year	No.	Av4	Md4	Av5	Md5
2008	34	3.6	3.5	3.6	4
2009	29	3.6	3	3.5	3
2010	33	4.7	5	4.5	5
2011	47	4.8	5	4.8	5
2012	62	3.8	4	3.7	4
2013_1	36	4.5	5	4.4	4.5
2013_2	15	5	5	5.1	5

where Av4 and Md4 are the average and median scores for Q4, resp., and Av5 and Md5 are the average and median scores for Q5, resp.

As can be seen, the number of students taking the course is increasing. Currently the enrolment in 2014 has again increased to about 80 students. Due to increasing enrolment, the class was split into two sections starting in 2013. This is the reason why there was a decline in the results in 2012. When the software engineering class was split into two sections, the results came back up. In summary, the results from 2011 – 2013 improved as compared to 2008 – 2010.

What is not shown in the results is the investigative framework that Blumenthal mentioned when doing PBL: How the students determined the requirements from the client by writing the SRS; how the students made plans on completing the project on time by writing the SPMP; how the students made the architecture design of the project using UML diagrams; how the students acquired the necessary skills in learning mobile technologies and languages through the help and guidance of the faculty/staff/student team; how they worked in teams; how they make presentations to the clients for demonstrations and getting feedback from them to build the next prototype. These were all performed and done by the students in the course of software engineering, which contribute to their work readiness and future careers in management when they graduate (Jollands 2012, Tynjala 2009).

4 UPPER MANAGEMENT AND ADMINISTRATION SUPPORT

The faculty/staff/student team could not have been successful without the support of the CSUSB upper management and administration. Support also came from the College of Natural Sciences and the School of Computer Science & Engineering.

4.1 Information Technology Division

The IT Division has been in existence since 1992. Its mission is to foster the evolution and development of information technology resource management and to encourage the integration and utilization of new and existing campus computing, communications, and media tools and applications. In addition IT also supports the teaching/learning process, research, scholarship and creative activities, academic/administrative services, and local regional public outreach. IT takes pride in that it is guided by the following principles:

-- Be responsive to the changing information

resource technology needs of a highly diverse student, faculty, and staff community.
-- Offer support and leadership through collaborative efforts with faculty, student, and staff.
-- In a participative manner, perpetuate information resource technology integration as a part of the academic and administrative fabric covering all programs.
-- Aggressively respond to the tactical objectives set forth by the campus strategic plan.
-- Advance CSUSB as one of the foremost teaching/learning environments in higher education by applying, as appropriate, technology solutions.

The Administrative Computing Service office of IT is the entity directly involved in the faculty/staff/student team. This is the office that provided the staff and supports the student interns for mobile app products. One of the missions of IT is to support teaching/learning process for students and so the faculty/staff/student team is directly relevant to this mission. The mobile app products that were created are relevant to being responsive to the changing information resource technology needs of a highly diverse student, faculty, and staff community.

Currently the campus is focused on delivering the core administrative system (PeopleSoft) and LMS to desktops via both wired and wireless connections with good reliability and maximum speed. In the past two years, the campus saw the increasing number of mobile devices connecting to campus networks and retrieving information in the same volume as desktops and laptops. ACS/IT recognized the opportunity to use mobile devices and partnered with the School of Computer Science & Engineering to form the faculty/staff/student team.

During the development of mobile app products with the faculty/staff/student team, there were sensitive information (such as enrolled classes, grades, student account information, and making payments) that must be kept secured while students and student interns are working on the mobile app products. So for security reasons, staff in the ACS developed service call libraries for student developers, which encapsulated the database connection configurations, SQL queries, and query result sets. Developers just need to reference the service calls and will receive the proper result for the mobile app needs without direct interaction with the student information systems, HR systems, or finance systems. In doing so, ACS is able to protect private and confidential information from the student developers but at the same time make the information available at the developer’s finger tips.

Two presentation/demonstration were made at the Administrative Council meetings: 01 August 2011 and 08 October 2012. The former president, Dr. Al Karnig, and current president Dr. Tomas Morales and the members of the Administrative Council were all impressed by the students’ presentation and all supported the faculty/staff/student team and the mobile app products that were presented and demonstrated. Another presentation/demonstration was made to the Philanthropic Foundation Board of Directors on 08 December 2011 and again all were impressed by the work and the professional way the students presented the mobile app product. President Karnig and other upper administration officers were present at that meeting.

4.2 Evolution of Faculty/Staff/Student Team

The mobile app products started in the undergraduate software engineering class (CSE 455) taught by Dr. Concepcion where prototypes were developed first and then continued development after the class is over. Then through students’ independent studies and senior projects and student interns working at the ACS/IT, the development is continued. The software engineering class is offered only in winter term, and in the following spring and summer, the faculty/staff/student team continued to work on the mobile app products until it is published usually in the fall term.

We started this cycle of development in winter 2011 when Sunny Lin and Tiffany Chiang from ACS/IT suggested to Dr. Concepcion to undertake a mobile app project in my software engineering class because ACS/IT had been wanting to start a capability in the campus to develop their own mobile app products. The winter 2011 software engineering class created the first prototype of CSUSB Mobile and after several former students of CSE 455 using independent studies continued working on the product in spring and summer 2011, CSUSB Mobile v. 1 was published in Fall 2011. The ACS/IT in summer 2011, created two student intern positions to maintain and continue the development of CSUSB Mobile.

The next winter 2012 software engineering class, the students created again prototypes of three new mobile app projects: CSUSB Library, CSUSB RecSports, and Tour CSUSB. Again several students continued the development via independent studies and senior projects, and in Winter 2012, these three new mobile apps were published in both the Apple App Store and the Google Play market. At this time, ACS/IT obtained a Student Vital Technology Initiative grant to support two additional student intern positions, bringing the total number of student interns at four. ACS/IT staff provided the support for student's use of the university servers and databases.

A supporting class is CSE 322 (Web Programming) which is taught by Dr. David A. Turner. In this class, the students learn PHP, JavaScript, CSS, and PhoneGap. These are programming languages and mobile technologies that are essential to mobile app projects. Although CSE 322 is not a pre-requisite to CSE 455, students who have taken this course before taking CSE 455 form part of a core of students who will be the major developers and programmers for the mobile app projects in CSE 455.

In winter 2013, Dr. Concepcion taught again the software engineering class and this time we had six new clients: Water Resource Institute, Student Advising, Coyote Radio, Museum, Sodexo, and Chancellor's Office "How to get to college." The whole process is repeated. The faculty/staff/student team is an appropriate model to use in sustaining the mobile app projects for a very long time.

5 QUALITY, PERFORMANCE, AND PRODUCTIVITY MEASUREMENTS

Tools such as the browser add-ons Firebug and YSlow! for Mozilla Firefox and the built-in Chrome Development tools were used to test load times, quality of code, number of external HTTP calls and DNS look-ups, and verify caching is in place.

Improvement was based on comparisons between major and minor versions. Page load speed, page size, reduction in HTTP calls, and quality of code were major factors in determining improvements throughout the application updates. Weekly meetings were held to discuss progress, improvements, and new features to implement.

The following are specifically measured: number of HTTP requests, gzip compressions, CSS and java script minification, number of URL redirects, avoiding invalid links, page load speed, and page size.

The measurement is determined by demand of Web traffic. Especially for high visited pages to understand how efficient we can deliver contents to end users. The categories of information we are collecting includes Web object name and path, method status, type size, latency, and over all timeline for delivery. The Firefox add-on YSlow! gives grade levels on these measurements and these grades are used as a basis for quality and performance.

6 CONCLUSIONS

In conclusion, the faculty/staff/student team is a very appropriate model of collaboration between the ACS/IT Division and the School of Computer Science & Engineering/College of Natural Sciences in creating the capability of the campus to produce mobile app products not only for the students in campus but also external entities that would require such services. The ultimate result is the greatest learning experience by the students. We have also shown that we can produce good quality mobile app products following the principles of software engineering.

6.1 Student Learning and Education

(Blumenfeld, 1991) stated that investigation by students is responsible for sustaining the doing and supporting the learning. Students in software engineering are encouraged to investigate and find answers that are not available in textbooks or in the classroom lectures, such as finding what the clients really want on the mobile app, how to design and plan the entire project so it delivered by the finals day of the term, studying new technologies and languages, searching answers on the different chat and Web sites, and other activities that are part of the development process but not taught in class. The SOTE scores reflect their perception on whether they are learning and how the instructor is teaching the course materials but they have actually learned when they deliver the completed mobile app by the finals day to the client.

The faculty/staff/student provided the sustaining and supporting the learning for PBL. This team provided the expertise and consultancy for students in software engineering for guidance and directions in the development of the mobile app products since about 90% of the students in class have never programmed in JavaScript, HTML5, CSS, Objective-C, XCode, and PhoneGap, and they needed the initial help and training in the first few weeks of the class to learn how to use these mobile technologies and languages.

Then after the software engineering class is over, the faculty/staff/student team continue the development of the prototype mobile app products until they are published in both Google Play and App Store later on. The team is assisted by several former software engineering students enrolled in independent studies or senior projects.

Although these were good benefits to the students' learning software engineering, there is also a weakness, which was described by (Lee 2012). This is called social loafing where some students may not perform as expected and thus create dissatisfaction within the team. Since the grade is given as a team grade, these students who did not perform also get the same grade. Last 2013, we have experimented on having the student project manager or the team lead, with the assistance and approval of the instructor, to "fire" the student who is not performing his/her task. The student who is fired is given another task by the instructor, which may or may not be related to the project being developed by the team.

6.2 Customer Satisfaction and Future Projects

As of this writing, CSUSB Mobile averages a solid 1.5K visitors per day, peaking at 2.5K unique visitors recently. Both CSUSB Library and CSUSB RecSports were announced as available for students use. The Tour CSUSB is going to be used as a recruiting tool both here in California and abroad. A second version is underway to be produced in four other languages: Korean, Japanese, Chinese, and Spanish. Our clients are very satisfied and are looking to upgrading their current versions. Five new mobile app products will be added this fall 2013: Sodexo Dining, RAFFMA Museum, Coyote Radio, Student Advising, and Slidewinder (an iOS mobile game).

Norco College, in partnership with CSUSB, obtained a Title V (Habilidades Unidos) grant for 5 years which began in Fall 2011. The goal of the grant is to establish a 2+2 pipeline bachelor's program from Norco to CSUSB in commercial music, graphics art, and mobile and game development. The first program is with the Department of Music, the second is with the Department of Art, and the third is with the School of Computer Science & Engineering. Both Dr. Concepcion and Dr. Turner are the faculty responsible for this part of the grant. The grant supports the faculty/staff/student team with equipment and computers needed for the mobile app products.

CSUSB benefits from this by having mobile app products available to campus students and we are sharing the development framework and software developed to all other CSU campuses. We are currently having communications with the Chancellor's Office, on the Distressed Students project. The Arrowhead Credit Union, a local company, has contacted us to build a charitable foundation mobile app for them. Sodexo, a world-wide company on food services, has agreed to develop a pioneer mobile app for their food service at our campus. Another local company, Innovative Economy Crowd, is consulting with us on an mobile engineering applications.

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Course Recommendation from Social Data

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Keywords: Recommender System, Social Network Analysis, Data Mining, Prediction, University Information System.

Abstract: This paper focuses on recommendations of suitable courses for students. For a successful graduation, a student needs to obtain a minimum number of credits that depends on the field of study. Mandatory and selective courses are usually defined. Additionally, students can enrol in any optional course. Searching for interesting and achievable courses is time-consuming because it depends on individual specializations and interests. The aim of this research is to inspect different techniques how to recommend students such courses. This paper brings results of experiments with three approaches of predicting student success. The first one is based on mining study-related data and social network analysis. The second one explores only average grades of students. The last one aims at subgroup discovery for which prediction may be more reliable. Based on these findings we can recommend courses that students will pass with a high accuracy.

1 INTRODUCTION

Recommender systems aim to prioritise information about items such as movies, music, books, news, images or web pages to users with respect to their interests. Jannach et al. (2011) presented different types of recommendations. The selection is based on the knowledge of user behaviour, information about behaviour of other users, and information about of all items in the database.

Recommender systems can be also used in an educational environment. Students have to pass many courses to finish their study. Some of them are obligatory, but optional courses have to be chosen by students. Students try to choose the best for them–interesting and passable courses, but it is very difficult to find suitable ones. Searching is very time-consuming and students have to search whole course catalogue, to examine abstracts and syllabi, to check success rate statistics or ask other students for their experiences.

To help students with their duties we intend to design a course enrolment recommender system that assists students when selecting courses. The recommendation is based on educational data mining and social network analysis methods. The recommendation is personalized for each student.

The course enrolment recommendation can be divided into two main parts: finding interesting courses and checking if the courses are not difficult for students. The second part is the most important. When a student enrols in difficult course and fail, the student can fail a study. The student would not use such recommender system. Previous experiment was published in Bydžovská et al. (2013).

This paper deals with recommendation of courses that will not be too difficult for a particular student. The aim of the proposed method is to predict student success or failure in selected courses. It is important not to recommend difficult courses for particular students and it is equally important to advise students about mandatory courses that usually cause problems to students. We aim at identification of such courses by using information that the courses were problematic for students with similar achievements.

The paper is organized as follows. In the following section, we present related work. In Section 3, we introduce the proposed recommender system. In Sections 4 and 5 we describe used data and in Section 6 we present experiments dealing with predictions of study success. Results can be found in Section 7. The discussion, summary and future work can be found in the last two sections.

2 STATE OF THE ART

A recommender systems overview used in education can be found in Manouselis et al. (2011). A common method to analyse educational data is to use educational data mining methods (see Romero and Ventura (2007)). It deals with the analysis of data for understanding student behaviour. These techniques can reveal useful information to teachers and help them design or modify the structure of courses. Students can also facilitate their studies using the discovered knowledge. Nowadays, researchers use educational data mining techniques mostly to guide student learning efforts, develop or refine student models, measure effects of individual interventions or improve teaching support.

One of the most important issues often solved in educational environment is understanding what influences student performance. The task involves the prediction of student's grades or student's course difficulties. This information can identify students with greater potential and also those that may require timely help from teachers or peers to fare well in the course.

Researchers usually mine from data stored in university information systems. Mostly, they use data such as grades, gender, field of study or age. Thai Nghe et al. (2007) concluded that better results were gained using decision trees than using Bayesian networks.

Vialardi et al. (2009) aimed to select courses for students in order to obtain good exam results. Difficulties of courses were compared with student potentials. Both variables were computed from grades. The work extension can be found in Vialardi et al. (2010) where the analysis was based on profile similarity. The results were satisfactory but the false positives obtained in results were too high. It is worse to recommend a course that students enrol in and fail than missing a course that they could pass. The solution was to sample the data again. It lowered the accuracy, but decreased significantly the false positive errors.

Another common topic of mining in educational data is the prediction of drop-out rate of students. Dekker et al. (2009) explored the possibilities of the assignment. The task is similar to the student's performance analysis but we are interested in the complex performance and in the chance to successfully complete their studies .

Our previous work also explored drop-out prediction (Bayer et al. (2012)). We collected useful information about students' studies. We applied educational data mining methods to this data. We then created a sociogram from the social data. We used social network analysis methods to this data and obtained new attributes such as centrality, degree or popularity, etc. When we enriched the original study-related data with these social attributes and employed educational data mining methods again, the accuracy of classification increased from 82.5% to 93.7%.

Marquez-Vera et al. (2011) used questionnaires to get some detailed information of students' lives directly from students because this type of data is not present in the information system, e.g. the family size, the smoking habits or the time spent doing exercises. These data can improve predictions about students failure.

In this work, we applied data mining methods to explore the study-related data. Unlike Marquez-Vera (2011) who was dependent on answers from a questionnaire, we used confirmed and complete data from the university information system. If compared with Thai Nghe et al. (2007) we tested broader spectrum of machine learning algorithms—bayesian, as well as instance-based learners, decision tree and also various rule-based learners. We further extended the method of Vialardi et al. (2009) by addition of social data. In this way we were able to compare students' data together with the information about their friends. Therefore, we could increase prediction accuracy.

3 A RECOMMENDER SYSTEM PROPOSAL

Students are interested in information resources and learning tasks that would improve their skills and knowledge. The recommender system should, hence, monitor their duties and show them either an easy or an interesting way to graduate.

The proposal of recommender system consists of three parts: data extraction module that extracts data from the Information System of Masaryk University (IS MU) database, pre-processing and analytical part (allows the user to select relevant features, to compute new ones, to obtain basic statistics about those features, and to run machine learning algorithms) and the presentation module (selects important knowledge and presents it to the user).

3.1 Use of the System

The proposed system will recommend mandatory courses and associated prerequisite courses. Elective and optional courses will be selected according to the student's potential with respect to vacancies in the timetable. The system will recommend interesting, beneficial and achievable courses for clever students. On the other hand, for weak students it will search for courses that can contribute knowledge to finish mandatory and elective courses.

Passing all mandatory and elective courses guarantees that a student deserves a university degree. When the system finds a difficult mandatory course for a student, it can inform him or her about the situation and the student can pay attention to the course and study hard. When a student needs to select elective or optional courses for a term, the recommender system selects interesting, but passable courses for a particular student.

The system will eventually recommend interesting and passable courses to students and will propose a short explanation of its decision and confidence. Students will have an opportunity to assess each recommendation if recommended courses were interesting and adequate difficult. Based on the assessments, recommendation algorithms will be modified to enhance the relevance of recommendations. The recommendations will be available for students of Masaryk University probably from autumn 2014.

4 SOCIAL AND STUDY-RELATED DATA EXTRACTION

Selecting attributes that express student's characteristics as accurately as possible is extremely important. Based on such data, we can give a better prediction on the courses that are crucial or interesting for a student. We tried to obtain such attributes that tell us as much as possible about students and their lives. The list of all attributes can be found in Section 5.1.

We believe that schoolmates who become friends have much in common. Although we cannot find it in the data, they can have similar sense of humour, close interests and maybe same intellect capability to be able to spend time and enjoy together. It is so far hypothetical, but very likely, that students with clever friends will have better study results than students with the same potential who do not have such friends. To observe this, we explore social ties among students.

4.1 Social Behaviour Features

There are a number of interpersonal ties that have been already evaluated to enhance IS MU full text search. Some ties are intuitive: (a) explicitly expressed friendship, (b) mutual email conversation, (c) publication co-authoring, (d) direct comment on another person. Weaker ties are more hidden and are derived from the following facts: (e) discussion forum message marked as important, (f) whole thread in discussion forum or blog marked as favourite, (g) files uploaded into someone else's depository, (h) assessments of notice board's messages, (i) visited personal pages.

We measured the value of a tie by its importance and weighted by a number of occurrences. As a result we calculated a single number from all mentioned ties reflecting the overall strength of student's relation with any given schoolmate.

A sociogram, a diagram which maps the structure of interpersonal relations has been created from information about students, their direct friends and relations among them. This allow us to compute new student features from the network structural characteristics and student direct neighbours attributes using tools for social network analysis, e.g. Pajek. These features give us a new insight into the data. The list of computed social behaviour attributes can be found in section 5.2.

5 DATA

We use three types of data: study-related data, social behaviour data and data about previously passed courses.

5.1 Study-related Data

This type of data represents student and his or her achievements.

Personal attributes: (a) gender, (b) year of birth, (c) year of admission, (d) capacity-to-study test score—a result of the entrance examination expressed as the percentage of the score measuring learning potential—minimum of all attempts to get at the university.

Historical attributes (include all student's outcomes achieved before the term in which the student attended the investigated course): (e) credits to gain—a number of credits to gain for enrolled, but not yet completed courses, (f) gained credits—a number of credits gained from completed courses, (g) a ratio of the number of gained credits to the number of credits to gain, (h) courses not completed—a number of courses a student has failed to complete, (i) second resits done—a number of used second resits (an examination taken by a previously unsuccessful student), (j) excused days—a number of days when a student is excused,

(k) average grades—an average grade computed from all grades obtained, (l) weighted average grades—average grades weighted by the number of credits gained for courses.

Term-related attributes (information about a term and a study in which the student enrolled in the investigated course): (m) field of study, (n) program of study, (o) type of study (bachelor or master), (p) a number of terms completed, (q) a number of parallel studies at the faculty, (r) a number of parallel studies at the university, (s) a number of all studies at the faculty, (t) a number of all studies at the university.

5.2 Social Behaviour Data

We computed social attributes for each student from sociogram we described in section 4.1: (a) degree—represents how many relations the student is involved in, (b) weighted degree—degree with respect to strength of the ties, (c) closeness centrality—represents how close a student is to all other students in the network, (d) betweenness centrality—represents student's importance in the network, (e) grade average of neighbours—calculation of average grades of the nearest neighbourhood values, (f) neighbours count in course—how many nearest neighbours have already enrolled in the course.

In our interpretation, the degree measures the amount of communication of each student. The closeness centrality measures distances needed to get some information from a student to all other students in the sociogram. The betweenness centrality expresses the frequency of a student in the information path between two different students.

5.3 Courses Passed by a Student

We added this type of data because we believed that the knowledge of passed courses is important and influences student performance. This type of data contained all passed courses for each student in the data set. We used only information about passing or failure in these experiments, we were not interested in exact grade because we observed that an exact grade is not important.

5.4 Data Sets

For exploring course difficulties we chose some courses of Masaryk University:

- IB101 Introduction to Logic
- IA008 Computational Logic
- IB108 Algorithms and data structures II
- IA101 Algorithmics for Hard Problems
- MB103 Continuous models & statistics

These courses are offered mainly for students of Applied Informatics, one of the programmes in the Faculty of Informatics. The choice was made with respect to importance of courses to students, how courses relate to one another, and the lecturers for the courses.

We generated two data sets for each of the above-mentioned courses. We used data from the years 2010-2012. As we aimed at predicting student success from historical data, the years 2010 and 2011 were used for learning. A test set then contained data about students who attended a particular course in the year 2012. A number of instances in the data sets is presented in Table 1.

Table 1: Number of instances.

Course	Data sets	No. of students	No. of vertices in sociogram
IB101	Training set	782	24829
	Test set	427	16649
IA008	Training set	158	6808
	Test set	73	5713
IB108	Training set	127	10652
	Test set	56	6335
IA101	Training set	219	11338
	Test set	113	9505
MB103	Training set	708	24018
	Test set	331	14495

6 METHODS

A recommender system core is an analytical module that exploits various machine learning algorithms from Weka (see Witten et al., 2011). The current version of the module contains three methods that comprise recommendation from complete historical data then learning based on grade averages, and also discovery of student subgroups for which a recommendation may be more promising. An obtained accuracy was always compared with a baseline, i.e. with the accuracy when all the data in a test set were classified into a majority class.

6.1 Mining Complete Data

The first method aims at classification of student's ability to pass an investigated course. We tested different machine learning algorithms—naive Bayes (NB), Support Vector Machines (SMO), instance-based learning (IB1), two rule learners (PART and OneR), decision tree (J48) and two ensemble learners (AdaBoost (AdaB) and Bagging).

Three experiments were performed that differ in granularity of a class—prediction of an exact grade A-F, prediction into three classes: good/bad/failure and two-class prediction of success/failure. We used three collections of attributes for classification: *All data* (study-related attributes together with social behaviour data), only *study-related data* (all study-related data without social behaviour data), *subset* of attributes (the best subset of attributes selected by feature selection algorithms—GainRatioAttEval, InfoGainAttributeEval and CfsSubsetEval). We also enriched all of the collections with information about students' previously passed *courses*.

6.2 Comparison of Grade Averages

The second method inspired by Vialardi et al. (2009) was based on a comparison of average grades of a student with average grades for the investigated course. The designed method also considered grades of students' friends. We computed the average grade from training set for all courses and predicted the study performance in the test set. The course average grade was compared with the student's potential, which was measured as follows: (a) average of student grades, (b) average of all student's friends' averages from the sociogram, (c) average of averages of student's friends that attended the investigated course simultaneously with the student. If the course average grade was higher than the student's potential, we predicted success and failure otherwise.

6.3 Recommendations to Subgroups

For subgroup discovery (see Lavrač et al., 2002, 2006) we combined discovery of finding interesting subsets of attribute values (by means of discretization for continues attributes and by building subsets of values for categorical attributes) with two learning algorithms—decision trees (J48) and class association rules (see Liu et al., 1998, Witten et al., 2011).

We first computed subsets of values for each attribute—from 5 to 10 bins in case of discretization, and couples and triples for categorical attributes—on the learning set. For each combination of such attributes we then learned decision rules extracted from decision tree (see Quinlan, 1993) and class association rules. From all rules with coverage higher than 5% of test set cardinality we choose those that had precision at least 5% higher than the best precision reached in the previous experiments.

7 RESULTS

The aim of these experiments was to recommend a course to a student based on the analysis of historical data. Some students rely on getting really good grades and not only on passing successfully, which is why we attempt to predict an exact grade and subsequently, either recommend a course or to warn a student not to enrol in the course. If the system recommended a course that is hard to pass or even non-passable for a student, the recommendations would not meet expectations.

7.1 Mining Complete Data

The results of the first experiment—classification into classes according to grades A, B, C, D, E, F (Table 2)—are not too convincing and also the accuracy improvement is quite small when compared with the baseline. It supports the observation that there is no strong difference between students when the difference in grades is small.

The obtained results of three class classification: good/bad/failure (Table 3) yield higher accuracy than the previous one. The maximum difference from baseline was observed for IB108—18%. If compared to Bydžovská et al. (2013), accuracy increased for 4 out of 5 courses. Only exception was MB103 where the accuracy remained unchanged.

Table 2: Classification into classes according to grades.

Course	Baseline	Data	Best results
IB101	40.74%	Subset + Courses	43.33% AdaB
IA008	34.24%	Subset	39.72% J48
IB108	17.86%	Study-related data	33.92% PART
		Subset	33.92% IB1
IA101	38.93%	All data	42.47% SMO
MB103	28.09%	Subset + Courses	32.63% Bagging

Table 3: Three class classification: good/bad/failure.

Course	Baseline	Data	Best results
IB101	68.38%	Subset + Courses	68.62% AdaB
IA008	56.16%	Subset + Courses	66.67% SMO
IB108	44.64%	Subset + Courses	62.50% NB
IA101	53.09%	Subset + Courses	65.49% AdaB
MB103	47.12%	Study-related data	57.70% Bagging

As we could see in results above, for grade prediction none of classifiers was able to reach accuracy significantly higher than baseline. For classification of success or failure (Table 4), the case was different. For success/failure prediction, for all of subjects, but IB101 there was slight improvement in accuracy. For IB108 the accuracy reached 82.14% what was more than 10% increase. Even higher increase—more than 25%—was observed for IA101. Data about students' previously passed courses improved the results in this case.

Table 4: Classification of success or failure.

Course	Baseline	Data	Best results
IB101	91.10%	Subset	90.16% SMO
IA008	83.56%	All data	89.04% SMO
IB108	69.64%	Study-related data	82.14% SMO
IA101	53.10%	All data + Courses	81.42% AdaB
MB103	69.48%	Study-related data	75.22% NB/Bagging

7.2 Comparison of Grade Averages

This method, as introduced in 6.2, was based on comparison of average grades of the student with average grades for the investigated course. In Table 5, (a) contains results when the student grade was compared with average grades of other students, with average of all student's friends' averages from the sociogram (b), and average of averages of student's friends that attended the investigated course simultaneously with the student (c).

This method resulted in slight accuracy increase in most cases for the choice (b)—average of all student's friends' averages from the sociogram. All results can be seen in Table 5.

Based on those results, we decided to build an ensemble learner that employs those three classifiers. A course is recommended to a student only if all three classifiers predict success. In the same manner, the course is not recommended if all three classifiers predict failure. Otherwise, the classifiers do not supply any recommendation.

Table 5: Prediction of student success from student potential.

Course	Baseline	(a)	(b)	(c)
IB101	91.10%	50.58%	91.29%	75.00%
IA008	83.56%	59.72%	84.28%	84.84%
IB108	69.64%	64.28%	70.90%	61.11%
IA101	53.10%	61.94%	46.90%	54.63%
MB103	69.48%	63.74%	69.48%	67.28%

The results in Table 6 show significant importance of social ties between students. It supports hypothesis that students having clever friends have higher probability to pass courses than the others.

Table 6: Ensemble learner of student potential.

Course	Successful students	Predicted to be successful	Precision	Recall
IB101	390	167	98.80%	42.30%
IA008	60	36	91.67%	55.00%
IB108	39	24	87.50%	53.84%
IA101	53	78	56.41%	83.01%
MB103	230	123	92.68%	49.56%

7.3 Recommendations to Subgroups

In this experiment we looked for subgroups with high precision of recommendations. The most promising attributes were: the average grade and the ratio of a number of gained credits to a number of credits to gain (*credits ratio*). The best results for each course are in Table 7.

Table 7: Discovered subgroups.

Course	Attribute	Range	Precision	Recall
IB101	Avg. grade	(-inf, 1.8>	98.60%	8.95%
IB108	Credits ratio	(-inf, 1.20>	85.56%	81.10%
IA101	Credits ratio	(-inf, 0.23>	77.40%	17.35%
MB103	Credits ratio	(-inf, 1.29>	96.43%	49.15%

We also explored manual invention of subgroups. We focused on the field of study and the year when the exam was passed. We observed that the accuracy increased between 2 and 4% for the field of study. However, this approach needs to be further elaborated.

8 DISCUSSION

We observed that use of social data together with study-related data resulted in accuracy increase in most of cases. On the other side, when using only social behaviour data, results were worse than when using only study-related data.

The most useful attributes were almost all social behaviour attributes—closeness centrality, both types of degree and betweenness centrality. The most promising attribute was closeness centrality. We may conclude that the most important is how fast a student can get a certain information from other students in the sociogram. Among study-related attributes it was an average of grades, a weighted average of grades, credits to gain, gained credits, a programme and a field of study.

The results were also improved by adding the information about student previously passed courses. The largest improvement was observed at course IA101. It may be caused by the fact that students usually enrolled in this course later than in the other courses that were included in this research.

The next observation concerns ensemble learner of student potential (Table 6 in 7.2). The learner significantly improved precision if compared with experiment from 7.1. The price is lower recall we are capable to give right recommendation only to a subpart (about 50%) of students. Concerning subgroup discovery, results for IA101 and MB103 were improved but we did not succeed in discovering an interesting subgroup for IA008. It may be also useful to combine the first two methods—machine learning and average grade comparison—and apply such an ensemble learner to promising subgroups of students.

We observed that experimental results were worse for courses that changed in the period of 2010-2012. That change may concern contents of the course or a way in which students have been evaluated. In that case learning and test data may not be from the same distribution what usually causes a decrease of performance, i.e. accuracy. To prevent from such a situation it would be necessary to check compatibility of historical (training) data and current (test) data e.g. by the methods described in Jurečková et al. (2012).

9 CONCLUSIONS AND FUTURE WORK

Our main contribution is to provide a method to use social data together with other educational data for course prediction. We presented three different methods to recognize and recommend passable courses to a student and warn against difficult ones. The proposed methods were validated on educational data originated in IS MU. We used different analytical tools, namely machine learning algorithms, comparison of student grade averages and employed also subgroup discovery. We concluded that for most of courses we could provide a recommendation to students.

There is still room for future improvements. Some of recommendations suffer from low confidence. In the future work we will use more detailed history of study. We also plan to introduce temporal attributes and to employ algorithms for mining frequent temporal patterns. We plan to extend data with time stamps (e.g. about the term in which a student passed a course) and to employ sequence pattern mining because the time sequence in which a student passed courses can be beneficial. The information system also contains data about online tests that a student passed and also information student access to online study materials. Such statistics enabled us to better understand student learning habits. Students learning continuously should be more successful than the others. We also intend to use the timetable data of course lessons. Some students can have problems with morning or late afternoon lessons and it can influence the course final grade. This information could enrich student characteristics and improve prediction. We can also enrich the data with information obtained from Course Opinion Poll where students evaluate courses, use similarity algorithms and predict the difficulty of the investigated course for a particular student based on the similarity of responds with others. We can compare our predictions with a student's subjective opinion about courses they have already passed and with results from similarity experiments.

Whenever a system will be running (we suppose that this autumn term is a realistic estimate) a student feedback will be the most important source of information.

ACKNOWLEDGEMENTS

We thank Michal Brandejs, IS MU development team colleagues and Knowledge Discovery Lab members for their assistance. We also thank Alex Popa for his help. This work has been partially supported by Faculty of Informatics, Masaryk University.

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STSIM: Semantic-web Based Tool to Student Instruction Monitoring

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Keywords: Semantic Web, Student Ontology, Student's Learning, Monitoring.

Abstract: In this article, a tool so-called STSIM is presented. It is able to monitor the student's progress along learning experiences. This tool, based on semantic web, allows students and teachers to monitor the knowledge student state including, among others, the learning objective state -achieved and not achieved- in different types of activities with psychomotors, cognitives or affective competences, and the efficiency accomplished in activity execution to facilitate the tutor or student the supervision of learning in a more adaptive way according to the individual characteristics and student knowledge state in each moment. To achieve this goal, STSIM uses a flexible student model supported by an ontology network, the *Student Ontology*. The tool has been developed to be multiplatform, multilingual, based on current and open-source web technology and characterized by its usability. STSIM is built on the UML-based web engineering (UWE) methodology and the Model-View-Controller (MVC) pattern.

1 INTRODUCTION

The technological advances have encouraged a bright evolution in many areas including the educational arena. In this way, one of the mostly researched aspects is the monitoring which, in general, consists of observing a situation, process, event, etc. through a receptor in order to check the quality and discover anomalies. In education, monitoring is a method that constantly analyses the student's evolution in correspondence with the proposed objectives. It allows teachers to ensure the process's direction; the software/human tutor can have a more accurate vision of the student's knowledge and, therefore, can take more informed and personalized tutoring decisions.

In this sense, it is important to highlight the difference between monitoring and supervision because both terms are often used interchangeably. Monitoring tries to find out if the student's evolution corresponds to the proposed objectives and, otherwise, the tool allows the responsible to take an adequate decision to correct the variations. Supervision is responsible for monitoring and making proper decisions.

A monitoring system is usually made up of the following components:

- **Indicators.** Measures summarizing the data.
- **Record.** Tools and methods to collect information.
- **Interpretation.** It analyses the stored data and
- **Visualization.** It shows the information in a specific instant.

The indicators, record and interpretation are necessary in all monitoring system. Nevertheless, the visualization is an optional component in all monitoring systems (Sampieri, 2008).

The tool explained in this article tries to progress in improving the quality of the educational system through the student's learning monitoring taking into account so many information sources such as the interaction possibilities derived from the use of Virtual Environments (VEs) to provide valuable information on the student's kwnowlede state, the student's behavior along different learning sessions, etc., so that the tutor can make sensible tutoring decisions or provide the most suitable feedback to the student in each moment. Thanks to it, STSIM may be easily used for differents learning environments and contexts in the short term. Furthermore, it is based on the semantic web process, specifically in the use of ontologies. There are multiple definitions about ontologies, but one of the most popular is the following: "An ontology is a formal and explicit specification of shared conceptualization" (Gruber et al., 1993).

This tool is supported by the Student Ontology (Clemente, 2011) consisting of an ontology network or, in other words, a collection of ontologies connected by some relationships such us mapping, modularization, version and dependency (Suárez-Figueroa et al., 2008). Student Ontology contains a wide range of types for modelling student in an Intelligent Tutoring system (ITS) and other complex learning environments such as the so-called Intelligent Virtual Environments for Training and/or Instruction (IVETs). The data registered in terms of the Student Ontology allows to carry out a pedagogical-cognitive diagnosis with non-monotonic reasoning capacities, that is able to infer the state of the learning objectives encompassed by the ITS and correspondingly infer the student's knowledge state (Clemente et al., 2013).

The article begins with a brief description of some important related work on the student's learning monitoring. The paper continues with a description of the adopted solution including a general overview of its architecture, design based on MVC pattern and technologies involved. Besides, some details on both the goals of present work and Student Ontology structure are given. Next, an application example is described. The paper ends with the main future work lines and conclusions.

2 APPROACHES TO MONITORING STUDENTS' LEARNING

The student's learning monitoring has been a highly researched topic since the last 20^{th} century when 12 modules for validating new technologies were identified including the monitoring (Zelkowitz et al., 1998).

Currently, there are some works closely related to student's learning monitoring which are worth emphasizing such as: a) the theorical study and the tool about the progress of student's learning (Sampieri, 2008). The tool consists of two modules supported by a database that can be used by teachers and student providing feedback to them through different graphs about the mark and efficiency during the course. b) the approach of OeLE platform (Sánchez-Vera et al., 2012). OeLE tries to evaluate the answers to open questions and to give feedback to teachers and students. Some of the most important characteristics of OeLE are the ability of monitoring the learning objective state and the use of ontologies.

Another important research line in this study is the feedback since it is essential that teachers and students receive suggestions to improve the teaching/learning process. From this perspective, we should highlight the work about data mining (Dyckhoff et al., 2011) involving the tool eLat. This tool offers support to teachers in the process of improving the efficiency in the group. It examines the

Table 1: Analysis of student's learning monitoring tools.

Tools	Author	Year	Technology	Objectives	Monitoring & feedback		Supervision		Indicators			Future potential
					Student	Teacher	Human	Software	Mark	Efficiency	Objectives	
eLat	Dyckhoff, A.L. et al.	2012	Data mining	Improve the course effectiveness	NO	YES	YES	NO	Participation in forums and number of request to content.			Medium
OeLE	Sánchez, M.d.M. et al.	2012	Ontologies	Evaluate the answers to open questions	YES	YES	YES	YES	NO	NO	YES	High
Check my activity	Fritz, J.	2011	Blackboard	Provide comparative reports to students	YES	NO	YES	NO	YES	NO	NO	Medium
LiMS	Sorenson, P. et al.	2010	Web	Extract the achieved objectives by the student	NO	YES	YES	NO	NO	NO	YES	Medium
ETR	Sampieri, M.	2008	Database	Monitor the student's learning	YES	YES	YES	NO	YES	YES	NO	Medium

number of mails sent by a student or the number of times that a student access to content of the subject and gives feedback to the teacher concerning the student's results. In this line, *Check my activity* was created (Fritz, 2011). This tool offers the students some comparative reports about the answers given by their classmates in an anonymous way. The aim of this tool is that the students receive feedback and ask for help when they need it.

Other interesting proposal that has been researched is LiMS (Sorenson and Macfadyen, 2010). This tool consists on the extraction of the objectives achieved by the students through contents published on the web.

In the table 1 a comparative analysis of some main features (year, used technology, objectives, monitoring and feedback, supervision, different indicators, future potential) of the mentioned tools related to student's learning monitoring as well as several main projects developed in the last five years (2008-2013) are shown.

As seen in Table 1, the related tools use different technology in order to profit from the advantages of each one. eLat use data mining in order to extract information to improve the course effectiveness. OeLE is the only tool based on ontologies in order to evaluate the answers to open questions. *Check my activity* uses the platform Blackboard to provide information to students. LiMS searches on the web to get the objectives achieved by students and ETR uses common databases to monitor the student's learning.

Moreover, the analysed tools have different monitoring and feedback targets. OeLE and ETR provide monitoring and feedback to teachers and students. Nevertheless, eLat and LiMS only provide the information to teachers and *Check my activity* gives information only to students.

Regarding supervision, it is important to emphasize that all tools allow the human supervision. However, only OeLE allows also the software supervision. This idea is essential because it offers a great potential in the future because mistakes can be detected and corrected more easily.

Another important aspect is the indicators which help teachers to understand the students. The mark is only measured in ETR and *Check my activity*. However, the efficiency is more exceptional because it is only measured in ETR. The objectives are considered in the OeLE platform and LiMS, respectively. Finally, eLat includes other indicators like participation in forums or number of requests to content.

3 PROPOSED SOLUTION

Our proposed solution to a monitoring tool is a Semantic-web based Tool to Student Instruction Monitoring (STSIM). It is a Java web application using a Model-View-Controller pattern. MVC facilitates the application's development (Leff and Rayfield, 2001), dividing the tool into three components:

- **Model**. It communicates the application with the Student Ontology through the Jena framework[1] and SparQL query language (Prud'Hommeaux et al., 2008).
- **Controller**. It contains the application logic communicating the Model with the View. It

[1] http://jena.apache.org/.

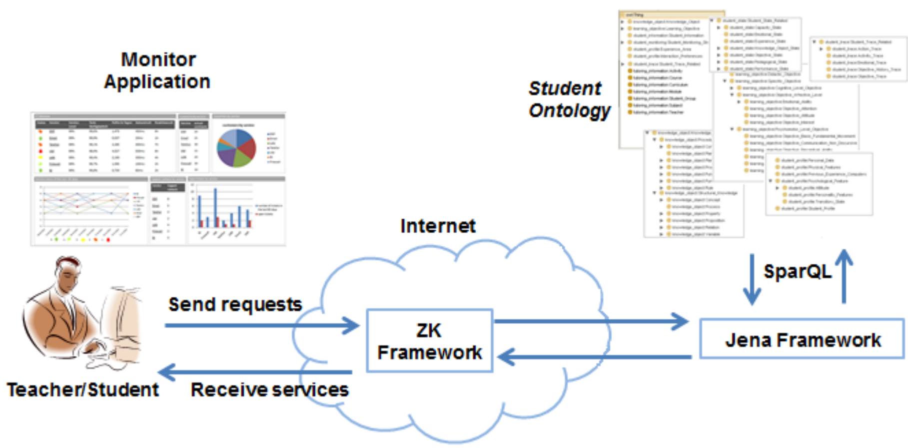


Figure 1: STSIM general architecture.

is implemented in ZK[2], a event-driven and component based pattern framework.

- **View**. It lets the user (teacher or student) request information from the Model and later, it generates an output representation to the user in several visual formats (graphics, tables, or plain text).

In the Figure 1, the different application components of STSIM and their connections are presented. The user interacts with the application Views through a web navigator. The Controller catches different actions from the users and requests to Model the required information. The Model consults the Student Ontology about the information which is sent to a new view in order to be visualised by the user.

STSIM is a web application built using UWE methodology. UWE (Koch and Kraus, 2002) is a web extension of the UML modelling standard.

The developed application tries to monitor the student's learning process in a subject matter based on an instructional design. It implies defining a group of activities and the objectives that the student should achieve in each activity. The relationship between learning objectives and the knowledge objects involved in a course is stored in Student Ontology. This representation is fundamental because it will allow a monitoring with different granularity levels; a monitoring of the reached or not reached learning objective states (coarse-grained monitoring) or a monitoring of student's specific knowledge state (fine-grained monitoring). In this way, monitoring the student's learning evolution provides greater assistance in the generation of a personalized plan for each student.

In STSIM, a instructional design of a course is used, which implies defining a group of activities for the subject matter to be taught and the objectives that the student should achieve in each activity.

As well as the objectives, other aspects can be monitored such as the mark in an activity or the efficiency in a course or activity. All these options are offered in the tool in order to provide teachers and students a more complete and better feedback about the student's learning.

3.1 The Student Ontology

The Student Ontology is, in fact, an ontology network composed originally by seven ontologies (Clemente et al., 2011). It was developed using the Protégé editor[3] and the ontology language OWL to be used, among others, in IVETs. It has been extended as support of the monitoring tool presented here with a new ontology so-called *Tutoring_Information* which contains information about teachers, activities, subjects and their relationships. Therefore, this ontology network is composed by the following main ontologies:

- **Tutoring_Information**. It includes, among others, the information about the student groups created in a course for a certain subject, teachers, modules or activities belonging to a subject, etc. In the Figure 2, the conceptual model of *Tutoring_Information* can be observed. It is composed by seven classes: (a) *Activity* contains the activity weight, required and achieved objectives and the module where it is located. (b) *Course* provides information about the associated curriculums and subjects. (c) *Curriculum* stores the syllabus it belongs to, its courses, etc. (d) *Module* offers information about its activities, objectives required and achieved by the module,

[2]http://www.zkoss.org/.

[3]http://protege.stanford.edu/.

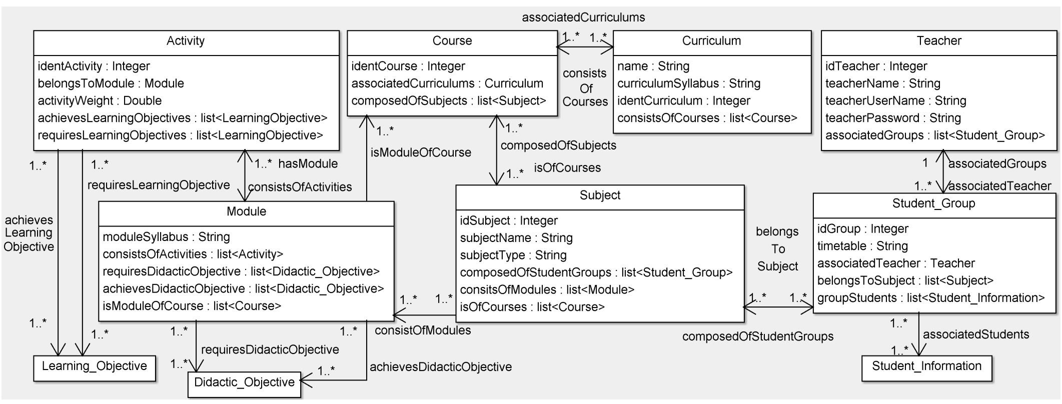


Figure 2: Conceptual model of *Tutoring_Information*.

etc. (e) *Student_Group* contains the data about timetable, teacher, students, etc. (f) *Subject* includes type, modules, etc. (g) *Teacher* provides some personal data, student groups who he/she teaches, etc.

- **Learning_Objective**. It represents the learning objectives defined in an educational process at cognitive, psychomotor or affective level. It is divided into Didactic_Objective and Specific_Objective.
- **Knowledge_Object**. It depicts a knowledge element which can be learned in a particular educational process. This ontology does not depend on any other.
- **Student_State**. It describes the student's knowledge, the acquired learning objectives, the degree of completion of the instructional design of the course, and an assessment of the student's performance throughout different learning sessions.
- **Student_Information**. It is created as an aggregate of all the information specific for each student. It includes the *Student_Profile*, *Student_Monitoring*, *Student_State* and *Student_Trace* ontologies. This ontology is also related to the new ontology *Tutoring_information*.
- **Student_Monitoring**. This single ontology allows us to define varied monitory strategies for the different variables that the tutor may be interested in monitoring (position of a student in the Virtual Environment, student's gaze direction, etc.).
- **Student_Profile**. It contains some personal information about the students (demographic data, preferences, physical and psychological features, etc.).
- **Student_Trace**. It describes the temporal registry of the student's activity during his learning experience in a subject.

A more detailed description of the above ontologies can be found in (Clemente et al., 2011). Additionally, a new simple ontology and the relationships with previous ontologies have been added to the ontology network: *Tutoring_Information*.

Furthermore, it is important to highlight that the Student Ontology was built using a modular network with the methodology NeOn (Gómez-Pérez and Suárez-Figueroa, 2009) because currently it is the only one that allows the development of ontology modular networks.

In the Figure 3, the ontology relationships between the different components of Student Ontology can be observed. The new ontology and its relationships with the previous already existing one, created in this work, (Tutoring_Information, Learning_Objective and Student_Information) appears in red color. The original ontology network is shown in blue color.

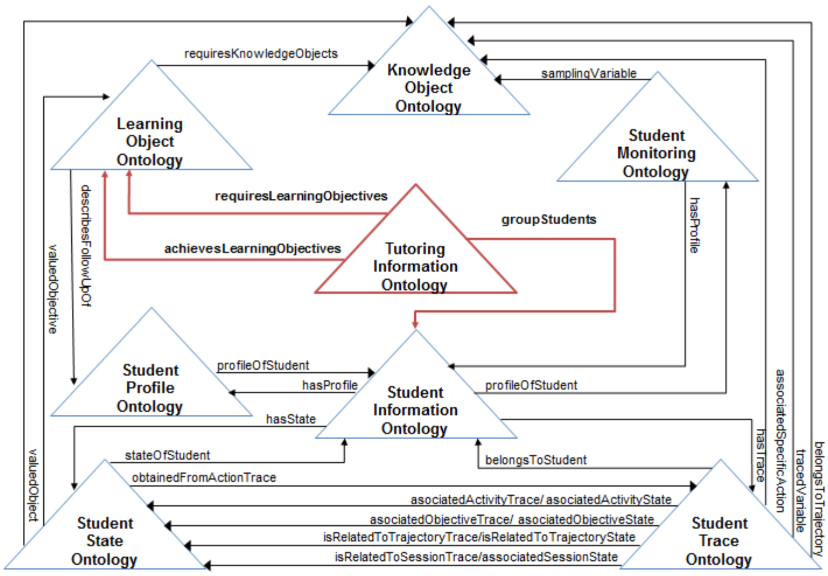


Figure 3: Ontology modular network in STSIM.

3.2 Objectives

The use of this tool is intended to provide teachers and students with some information[4] which lets them prepare a specific learning plan for each student according to their current knowledge state and their particular characteristics.

Furthermore, other important objectives pursued with the development are:

- **Extensibility**. The application is characterized by the extensibility in the used student modelling (Student Ontology) and in the application development.
- **Multiplatform**. It represents the possibility of using the tool in different Operating Systems and web browsers.
- **Multilingual**. The tool should be provided in different international languages and it offers the possibility to add new languages easily.
- **User-friendly**. The users of this platform will only log into the web application. Moreover, the application will offer different alternatives of help such as pop-ups and an user's manual in order to show the user all the possibilities to take advantage of the monitoring application.
- **Based on Semantic Web**. It is intended to use the semantic web technology, in particular, ontology technology since it offers reusability, extensibility and the possibility to infer knowledge that, in the future, could help in the supervision task.

[4]In the current initial state of STSIM tool, the large amount and diversity of stored information in the used ontology network is not being exploited more than at very low level for monitoring student's learning evolution.

4 TOOL EXAMPLE

In this sense, the learning objectives associated with the activity `Development of a minishell` have been previously defined within a pedagogical design. The initial state for the objectives in each learning activity depends on several factors such as tutoring strategy, student's background, whether the objectives have already been reached in previous activities, etc. We suppose that the student has not already acquired the required theoretical knowledge to do the practice so, we assume the initial state *acquired=false* for the objectives. Besides, the Student Ontology provides instances about the knowledge objects involved in the course *Operative System*; the dependencies between the activities objectives and the knowledge objects; students' profile; subject information (modules, activities, teacher(s), student's groups, etc.). The students answer questions and, consequently, some rules are fired and the ontology content is updated with the new objective states (achieved or not achieved) (Clemente et al., 2013). Thereafter, we can see in Figure 4 and Figure 5, STSIM allows users (student/subject teachers) to see student's learning monitoring data though graphics, tables and plain text. Also, STSIM presents a great potential in the near future taking advantage of ontology inference capability, specifically, inferring from the information stored in the Student Ontology.

The Figure 4 shows four groups of bars. The first is the mark percentage, the second is the correct answers percentage, the third is the incorrect answers percentage and the forth is weight percentage which has been obtained by the student *Antonio Martín Pérez* in activity *Development of a minishell* of *Operating Systems* subject on a degree course in *Computer Science*. The red bars represent the student attributes, the blue bars show the average values of the

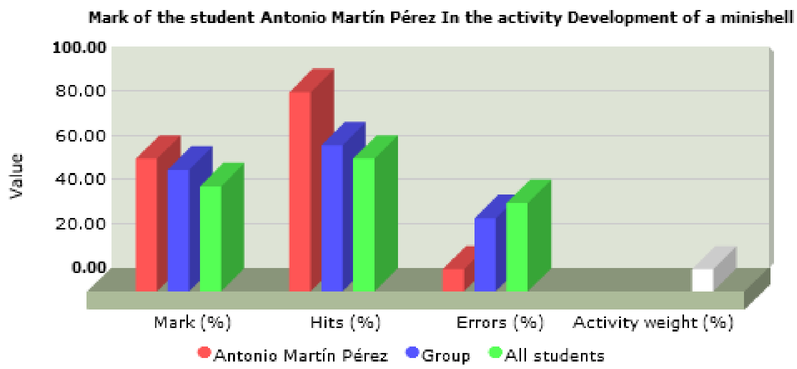
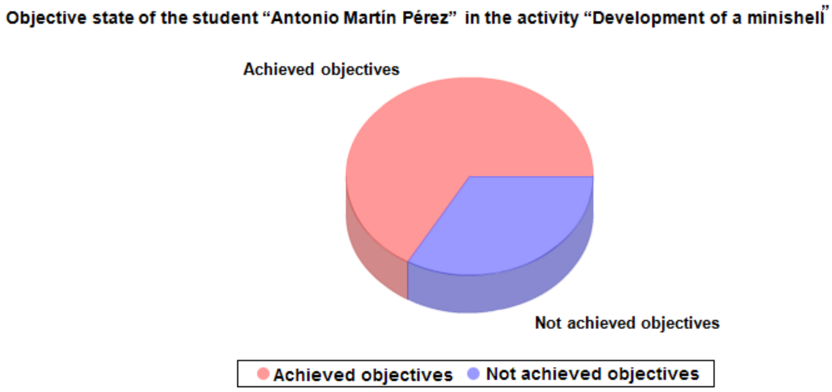


Figure 4: Mark obtained by a student.



Objective	Achieved
Being able to understand the basic functions in a shell	☑
Being able to understand the difference between background and foreground execution.	☑
Being able to understand the difference between internal order and external order in Unix / Linux.	☐

Figure 5: Learning objective states of a particular student.

student group, the green bars depict the average of all the students that have carried out the activity and the white bar stands for the activity weight on the subject.

The Figure 5 represents the objectives achieved and not achieved by the student *Antonio Martín Pérez* in the activity *Development of a minishell* of *Operating Systems* subject on a degree course in *Computer Science*. At the top of the figure, a pie chart with the achieved and not achieved objectives is shown and at the bottom of the figure, a table indicates the specific objectives achieved and not achieved by the student in the above-mentioned activity.

Despite teachers and students can monitor objective state, the teacher has more options for monitoring because it can monitor a student, a student group or all groups of a subject taught by him. However, the student can only monitor himself and obtain the averages of his student's class.

5 FUTURE WORK

With the tool presented in this article, we intend to open several lines of future work. The first and most important line of research consists on using automated tools such as planners (Plaza et al., 2008) may provide support for the planning and supervision of the student's learning evolution taking to support monitoring output of STSIM tool.

Another working lines are related to enhancing the tool development:

- From a functional point of view: a) the monitoring tasks can be extended with other key indicators to monitor the student's learning process. It includes, information such as the relationship between the objective states (achieved or not achieved) and its associated learning objects. Likewise, from this focus, using the tool in Intelligent Virtual Environments (IVE) provides teachers much information about student's knowledge states based on information related to these environment types already registered in terms of Student Ontology. b) Using semantic technology to infer additional knowledge from the information stored in the ontology allows the teacher to adopt tutoring decisions more adaptable to the particular characteristics and knowledge states of each student at every moment of their learning. c) Carring out a survey of accessibility and usability of the tool developed using standard techniques and tools. From the previous analysis, adequately improve in the tool (Slatin and Rush, 2003). d) Extending the multilingual capability of STSIM (currently it is offered in English, French, German and Spanish). e) Adapting the web application to be used in different environments and types of activities like forums, physical tests, etc.
- From a structural point of view: extending the ontology of the student in some weak points. For example, in learning objective ontology, student profile ontology (personal characteristics that influence student's learning), or other aspects not yet covered as tutoring strategies. In this line, perhaps other ontological or not ontological resources currently existing in repositories, etc, could be reused.

The great potential offering this project is the future line implementation because the technological advances in semantic web are able to provide improvements in the educational field. In a future, this tool will be able to be implemented into different environments and work in a collaborative way with other ontologies and monitoring tools.

6 CONCLUSIONS

This article has described a solution to monitor the student's learning process. The general goal of this work has been the development of a monitor tool so-named STSIM, based on web and ontology technology with the following main characteristics: available for teachers and students, multilingual, multiplatform, easily extensible, user-friendly and developed using the framework ZK, a Web application framework based on patterns and events, and Jena framework.

Besides, it is worth mentioning the importance of monitoring as information source to the human supervision (tutor or the student throughout his learning) or software supervision because it has a great potential to detect weaknesses in the student's learning process using ontological inference and monitoring information.

We should emphasize the importance of the use of ontologies and its advantages, including the the ability of inference from their knowledge. It can benefit and enrich greatly the monitoring and supervision of student's learning and, ultimately, encourage advance towards the improvement of educational processes, essential goal of our work. A wide representation of information relating to complex environments such as the Virtual Environments for Training/Instruction, whose benefits have been proven in the field of education (Mantovani, 2001) and, specifically, the IVETs, already exists in the ontology network used in STSIM tool that can be exploited and extended in the future to achieve the final goal.

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Unlocking Serendipitous Learning by Means of Social Semantic Web

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Keywords: Serendipitous Learning, Social Semantic Web, SKOS, SIOC.

Abstract: Serendipitous Learning is the learning process occurring when hidden connections or analogies are unexpectedly discovered, mostly during searching processes (for instance on the Web) which are typical for informal learning activities, especially accomplished in the workplace context. Moreover, serendipitous processes have high probability to occur in the contexts where learners have high autonomy, more chances to intervene in different activities and to interact with resources and people. This paper proposes an approach, based on the Social Semantic Web, to sustain and foster Serendipitous Learning. The proposed approach considers two connected ontology layers to model knowledge by using several Semantic Web vocabularies like SIOC, Dublin Core, SKOS, and so on. The SKOS role is particularly relevant because it allows connections among heterogeneous resources, also across multiple communities. The proposed approach models the above-mentioned connections at the conceptual level in order to facilitate learners to discover relevant links, concepts and to follow unexpected useful paths.

1 INTRODUCTION AND RELATED WORKS

Technologies and, in particular, ICTs (Information and Communication Technologies) influence the educational practices as well as the redefinition of the concepts of learning and teaching. This phenomenon asks educators to review their practices in order to face new learning/teaching situations in which learners can access alternative learning resources in addition to those defined in structured curricula. The availability of new learning resources is mainly due to the Web, intended as a boundless field of information. The increasing number of learning resources (on the Web) and the decreasing of teacher presence require higher autonomy and regulation to learners in order to master both formal and informal learning environments. Autonomous and self-directed interactions with available content foster *"[...] unexplored and unplanned discoveries and fortunate incidents in the process of exploring something else [...]"* (Kop, 2012). In this context, the term *serendipitous learning* was coined to point out the learning processes related to the *"[...] unexpected realization of hidden, seemingly unrelated connections or analogies [...]"* (Kop, 2012).

This paper describes how *Social Semantic Web*, if opportunely deployed, is able to effectively sustain *serendipitous learning*. *Social Semantic Web* (Breslin et al., 2009) is defined as the synergistic application of Semantic Web and Social Web that tries to get and combine the advantages of both. The work provides a scalable approach to manage knowledge and contents created in a specific environment. It mainly focuses on both the formal description of relevant resources (e.g. Web resources) in the environment and the modelling of conceptual connections among the above-mentioned resources. The approach proposes a knowledge representation architecture based on two integrated layers of ontologies in order to foster the emergence of relevant connections among resources and the agile provisioning of these connections to the learners, helping them to play a serendipitous learning experience. The approach could be exploited also in smaller contexts like, for instance, Small and Medium-sized Enteprises (SMEs), where the concept of Web resource is replaced by the concept of digital resource. Other works in literature deal with the adoption of the Social Semantic Web as a learning platform. In particular, the authors of (Jovanovic et al.,), (Torniai et al., 2008) and (Jeremic et al., 2013) were among the first ones to describe the e-learning scenarios supported and enhanced by the Social Semantic Web technologies and methodologies and to discuss the main issues concerning the realization of these scenarios:

- development and maintenance of domain ontologies;
- exploitation of user-generated contents as learning resources;
- provisioning of new forms of interaction;
- support for interoperability;
- support for adaptation and personalization of e-learning experiences;
- ubiquitous access to learning resources.

Moreover, the authors of (Brooks et al.,) provide three main lessons learned by analysing e-learning applications and tools developed by using Semantic Web and Web 2.0 technologies:

- testing the defined approaches in real world scenarios in order to effectively evaluate systems and validate models and methodologies;
- tracking large amount of data related to learners' interactions in order to extract pedagogical patterns;
- extracting implicit knowledge from contents in order to automatically construct metadata to improve search of learning material.

With respect to the reviewed literature, this paper mostly focuses on the anatomy of the ontology structures (two integrated layers of ontologies have been introduced and modelled) and on the methods for constructing, maintaining and evolving the aforementioned ontologies. More details concerning the discovery of links and related resources have been provided by proposing several approaches. If the Semantic Web technologies provide a great solution for interoperability and integration, discovery is considered one of the main lever to enable serendipity. This paper takes care of principles and suggestions of the existing works and advances by trying to solve some of the main issues related to the adoption of Social Semantic Web in e-learning scenarios. Lastly, it is important to underline that the proposed approach aims at working in contexts (e.g. Knowledge-Intensive Organizations) where the ICTs are already exploited to manage and track (also partially) the work activities.

2 SERENDIPITOUS LEARNING

The idea underlying *serendipitous learning* is based on several pedagogical approaches. Among the others, it is possible to recognize *discovery learning*, *exploratory learning*, *experiential learning*, *constructivist learning* and *connectivism* (Kop, 2012). Numerous works (Heinström, 2007) address *serendipitous learning* by taking care mostly of the concept of surprise and on the accidental nature of information discovery. On the other hand, some authors (André et al., 2009) focus on the importance of prior knowledge and sagacity in the *serendipitous learning* processes. Other scientific results affirm that the hidden connection discovery could not occur instantly but require an incubation period to the learners (McCay-Peet and Toms, 2010) (Lu, 2012). These authors assert also that the conditions able to sustain serendipitous connection discovery are those of *active learning* and *social learning* in *knowledge building and discovery* environments (Scardamalia and Bereiter, 2006) (McCay-Peet and Toms, 2010). Furthermore, the effects of serendipity are analysed by the authors in (Gritton, 2007). They assert that there is not sufficient evidence to affirm that *serendipitous learning* is a consequence of intuitive sagacity of learners but they state that there is no doubt that serendipitous browsing can reveal hidden connections among concepts and stimulate thinking and, consequently, learning. Now, the question is: *may the new Web technologies increase and improve serendipitous learning?*. Some ideas are proposed by authors of (Ihanainen and Moravec, 2011) and (Boyd, 2010). They enhance search strategies (e.g. the same adopted by Web search engines) by moving the control from search engines to learners and by fostering randomness in the information stream. Authors of (Boyd, 2010) affirm also that people should find methods for integrating Web searching into their thinking and reflection processes. Technologies have to take care of this integration and the personal context of the learner by considering *an unfiltered but manageable store of resources*.

3 A SOCIAL SEMANTIC WEB APPROACH TO IMPROVE SERENDIPITOUS LEARNING

In this Section, an approach that fosters serendipitous learning is proposed. The approach is based on the main Social Semantic Web principles in order to provide Web-based environments to interact (searching, tagging, rating, recommending, etc.) with digital resources.

3.1 The Social Semantic Web

The W3C[1] provides the following brief definition for Semantic Web: *[..] The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries [..]*. The Semantic Web vision concerns the provisioning of metadata associated with Web resources to assign *machine-interpretable meaning* to them. In order to make this metadata really sharable and understandable, it requires vocabularies and ontologies expressing semantics for terms and values used in the above-mentioned metadata. Being these metadata set represented in uniform way, better linking and decentralization of resources are supported. Among the other issues, the Semantic Web infrastructure provides concrete answers to the requests for *entity identity* and *explicit relationships*. More in details, with Semantic Web, the entities on the Web, previously embedded and hidden in HTML pages, become uniquely identifiable and, thus, understandable and manageable by machines (computers). Moreover, representing entities is not sufficient, thus identifying relationships among entities is also needed (Breslin et al., 2009). In other words, Semantic Web allows the development of software agents that aim at improving search and navigation of Web resources, making new user experiences available. From the technological viewpoint, the core of the Semantic Web architecture[2] is represented by: i) RDF (Resource Description Framework), i.e., a data model natively enabling distribution of data, ii) RDFS (Resource Description Framework Schema) and OWL/OWL2 (Web Ontology Language), i.e., languages for formal description of data and its semantics. These two main layers, supported by URIs and XML, allow querying (by using, for instance, SPARQL) and inference (by using ontology-based inference enabled by OWL reasoners or rule-based inference enabled by specific rule engines). On the top of the core layers, a great number of vocabularies and ontologies, covering different domains (some more specific, others more general), have been developed and deployed. FOAF (Friend of a Friend)[3] for representing knowledge on people and social relationships, SIOC (Semantically-Interlinked Online Communities)[4] for representing knowledge on activities of on-line communities, Dublin Core for describing metadata for (digital) resources, SKOS (Simple Knowledge Organization System)[5] for modelling thesauri, concept maps and controlled vocabularies, SCOT (Social Semantic Cloud of Tags)[6] & MOAT (Meaning of a Tag Ontology) (Passant and Laublet, 2008) for modelling all the entities related to the tagging process, and so on.

In this context, the concept of *Social Semantic Web* emerges. Social Semantic Web represents the ecosystem in which social interactions on the Web applications lead to the creation of explicit and semantically rich knowledge representations. The Social Semantic Web combines technologies, strategies and methodologies from Semantic Web, social software and the Web 2.0 (Weller, 2010). In other words, the Semantic Web provides new and better searching (for people, content, tag, etc.) scenarios for Social Web applications and, vice-versa, users' interactions with Social Web applications extend, update and populate the Semantic Web structures.

SIOC (Bojārs et al., 2008) is one of the most important and known ontologies for the Social Semantic Web. It aims at interlinking on-line user-generated content from applications such as blogs, instant messaging tools, wikis and other Social Web sites, by providing an ontology to model structures (e.g. posts, threads, etc.) and activities (e.g. tagging, replying, etc.) in online communities. Typically, SIOC is used in combination with the FOAF vocabulary for describing people and their friends and the SKOS model for organising knowledge. SIOC lets developers link discussion posts and content items to other related discussions, items, people and topics. Authors of (Bojārs et al., 2008) introduce also the concept of *food chain* (see Fig. 1).

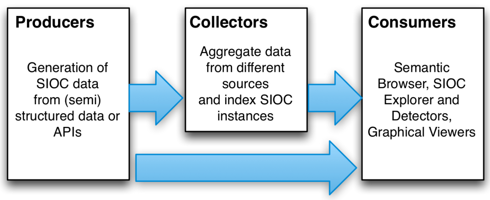

Figure 1: SIOC food chain.

The idea is that semi-structured data is gathered and transformed in SIOC data from different sources. Subsequently, SIOC data coming from different sources is aggregated (by using the native capabilities of RDF data model) and indexed (e.g. with SKOS taxonomies). At the end of the chain, users can search and navigate integrated SIOC structures also by surfing the defined indexes.

[1] http://www.w3.org/2001/sw/
[2] http://www.w3.org/standards/semanticweb/
[3] http://www.foaf-project.org
[4] http://sioc-project.org
[5] http://www.w3.org/2004/02/skos/
[6] http://scot-project.net/scot/spec/scot.html

3.2 Generalizing the SIOC Approach

It is possible to generalize the SIOC (Breslin et al., 2006) approach by considering different types of data source and not only Social Web applications. The idea is to provide additional ontologies, to integrate with SIOC, to cover different domains. For instance it is possible to use Dublin Core to describe documents in Document Management Systems (DMSs), IEEE LOM (a binding in RDF[7]) to describe learning objects in Learning Object Repositories (LORs) and so on. Fig. 2 shows a generalization of the SIOC food chain and proposes SKOS as a mechanism to integrate and index different types of individuals.

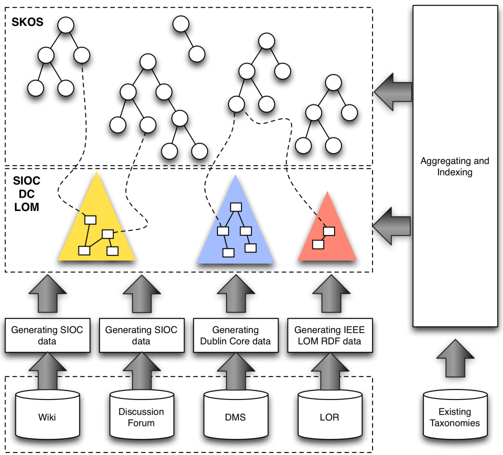

Figure 2: Generalizing the SIOC food chain.

Fig. 2 clearly shows two ontology layers, the upper layer (in Fig. 2), realized by means of SKOS, provides *classification ontologies*, i.e., lightweight semantic structures used to annotate and classify individuals belonging to the ontologies at the lower layer. The lower layer provides *descriptive ontologies* which model key concepts of the domain of interest. For instance, in a Knowledge-Intensive Organization (KIO), the key concepts like Project, Task, Activity, Document, UGC (User-Generated Content) should be considered and modelled by using the ontologies at the lower level (Mangione et al., 2012) (Gaeta et al., 2013). These ontologies are, relatively, static in the sense that they do not rapidly evolve and have to be built and managed by human experts following methodologies like NeON (Suárez-Figueroa, 2010) also by adopting (as suggested in this work) existing vocabularies. Ontologies at the upper layer are dynamic, in the sense that they evolve as soon as new activities (dealing with new topics) start in the KIO. These ontologies model and structure, for instance, the topics of the projects in the KIO. The *classification ontologies* can be constructed by means of automatic, semi-automatic or non-automatic processes. More in details, the automatic process can be realized by means of *Fuzzy Formal Concept Analysis (FFCA)* (Maio et al., 2011) that is used to extract concepts from a set of full-text documents and construct a *Fuzzy Concept Lattice*, i.e., a structure that represents the conceptualization of the document set taken as input. The same authors define a methodology to build SKOS ontologies starting from a *Fuzzy Concept Lattice*. If the considered documents are packaged as structured learning contents it is possible to adopt approaches like, for instance, those provided in (Capuano et al., 2009) and (Gaeta et al., 2011), where the content structure is exploited to construct lightweight ontologies from the source learning material. Definitely, the combination of the two ontology layers allows interoperability, integration (in particular *descriptive ontologies*) and serendipity (in particular *classification ontologies)* as we will show in the next Sections.

[7]http://ltsc.ieee.org/wg12/

3.3 Using SKOS to Link Heterogeneous Contents

In the Semantic Web, SKOS provides a vocabulary to define thesauri, taxonomies, controlled vocabularies, concept maps and so on. SKOS provides the `skos:Concept` class that can be instantiated in order to define individual concepts (or subjects, topics, tags, etc.) which can be hierarchically related by means of `skos:narrower` and `skos:broader` (Baker et al., 2013). Other relations among individual concepts can be expressed by means of `skos:related` (for weak semantic relations) or by defining subproperties of the above mentioned properties, including `skos:semanticRelation`. Moreover, two concepts belonging to two different SKOS taxonomies can be related by using `skos:relatedMatch`, `narrowMatch` and `broadMatch`.

According to the need of indexing and integrating individuals coming from different classes (of different vocabularies), it is important to introduce two properties: `sl:isSubjectOf` and `sl:subject`. The first one is the inverse of the second one that is defined as a subproperty of `dct:subject`[8] (coming from Dublin Core vocabulary).

Moreover, `sl:subject` has range `skos:Concept` whilst `sl:isSubjectOf` has domain `skos:Concept`. More in details, as shown in Fig. 3, by means of the `sl:isSubjectOf` property it is possible to assert that

[8]http://dublincore.org/documents/2012/06/14/dcmi-terms/?v=terms#terms-subject

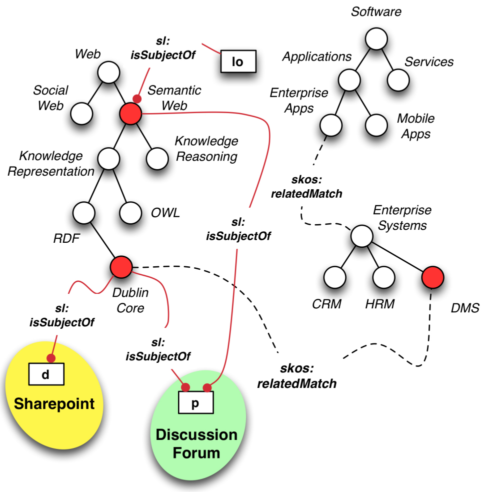

Figure 3: SKOS to link heterogeneous contents.

both the document `d` and the (forum) post `p` deal with the topic `Dublin Core`. The post `p` also deals with the topic `Semantic Web`. The concept `Dublin Core` is related to the concept `DMS` of a different concept schema, as well as the concept `Enterprise Apps` is related to the same concept `DMS`.

Definitely, as we will see also in the next Section, the *classification ontologies* represent the core structure enabling the serendipitous discovery.

3.4 Serendipitous Learning in the Social Semantic Web

According to the example provided in Fig. 3, assume that user `A` is interested in the concept `DMS` because she has to introduce a Document Management System in the SME (Small and Medium-sized Enterprise) she works for. While addressing the `DMS` concept, `Dublin Core` concept is signalled to `A` because it is related to `DMS`. Once the attention of `A` is focused on `Dublin Core`, she learns that `Dublin Core` is related to `DMS` (we assume that a standard viewer, for a SKOS ontology, shows and emphasizes at least all the concepts directly linked to the concept the user is currently addressing) and she can see two resources (coming from two different systems) dealing with the aforementioned concept. By reading the text document `d`, `A` goes deep into her knowledge on the connection among `Dublin Core` and `DMS`. `A` learns that some existing Document Management Systems represent document metadata by means of Dublin Core schema.

Moreover, `A`, by reading the forum post `p` understands that the use Dublin Core follows the principle of the Semantic Web, a concept that is unknown for `A` until this moment. `A` acquires knowledge about the `Semantic Web` concept by enjoying the learning object `lo`.

This sample flow emphasizes the main principles of *Serendipitous Learning*:

- Fostering autonomous interaction of users-learners with content space;
- Valorizing the users-learners' prior knowledge (in the out-of-the-box thinking) by means of SKOS concept schemas which recall the human mind model;
- Stimulating *surprise* (by showing hidden connections) during exploratory processes;
- Providing active and social learning space aiming at knowledge building processes.

The relations among concepts (`skos:Concept`) and Web resources (i.e. the *Aggregating and Indexing* process of Fig. 2), in the Social Semantic Web platform could be generated with non-automatic, automatic and semi-automatic mechanisms. In the first case, it is possible to exploit the tagging features of Social Web applications and integrate tagging ontologies like, for instance, SCOT and MOAT with SKOS. In the second case, it is possible to exploit *knowledge extraction & discovery* methods like, for instance, *FFCA* (see Section 3.2) that is able to conceptualize a set of full-text contents and automatically classify them with respect to the extracted concepts. It is also possible to recommend some of the connected resources to the learner, on the basis of his/her profile (Gianforme et al., 2009) in order to foster his/her discovery process.

A sample result of this process is depicted in Fig. 3 where the *FFCA* algorithm extracts the concept `Dublin Core` from two contents, i.e., document `d` and post `p`. The relation among the two contents and the extracted concept is explicitly asserted (in the RDF/RDFS/OWL sense) by means of the `sl:isSubjectOf` property. The third case foresees the application of the aforementioned methods, whose results are supervised and revised by means of human interventions.

An important aspect of the proposed approach is its capability to link concepts belonging to different *classification ontologies* (*cross-ontologies* links). Several methods can be exploited to discover *cross-ontologies links*. One of the simplest ones is to calculate the *document-oriented word similarity measure* (Terra and Clarke, 2003) among the labels which describe two different concepts:

$$rel(c_1, c_2) = \frac{df_{c_1,c_2}}{N_{max}}. \tag{1}$$

In the equation 1, df_{c_1,c_2} is the number of contents annotated with both concept c_1 and concept c_2

(coming from two different SKOS ontologies, i.e., individuals of `skos:Concept`). Whilst N_{max} is the total number of considered contents. An instance of the property `skos:relatedMatch` is asserted among c_1 and c_2 if $rel(c_1, c_2)$ is bigger than a given threshold.

3.5 Using SPARQL to Access Contents and Concepts

The proposed approach enables high interoperability and integration by laying upon the Semantic Web stack. This capability allows to navigate on the ontology graphs by using the SPARQL language and obtain useful results (able to concretely realize the scenario depicted in Section 3.4) by means of simple queries, like the following one.

```
...
SELECT ?s ?obj
WHERE
{
  ?s1 skos:relatedMatch unisa:DMS .
  ?s1 sl:isSubjectOf ?obj .
  ?s sl:isSubjectOf ?obj
}
...
```

The previous query (it is only a sample code) allows to retrieve all concepts related (in the example we consider only the cross-ontology links) with `DMS` and all contents (the result parameter is `?obj`) annotated with these concepts. The retrieved contents are further analysed in order to found other relevant concepts (the result parameter is `?s`). This is the way to discover that `Dublin Core` follows the principles of the `Semantic Web` (see the scenario described in Section 3.4).

Lastly, the inference capabilities provided by the ontology-based reasoners (supporting RDFS, OWL and OWL2) generate new facts (from existing ones) which increase the knowledge base and, consequently, enrich learners' exploration experience.

3.6 Identifying Relevant Paths: A Data Mining Approach

Suggesting hidden connections (among concepts and, conseuently, resources) is one of the main chances to provide surprise to learners during the exploratory process. The method we propose is based on the *Context-Dependent Sequential Pattern Mining* algorithm. The idea of traditional *Sequential Pattern Mining* (Pei et al., 2004) applied to the domain of this paper is that the exploratory paths of learners, in terms of visited concepts (on the *classification ontologies*), can be analysed in order to find frequent sequences of visited concepts. For instance, the algorithm can assert something like this: *learners who visit concepts* c_x, c_y *and* c_z *also visit concept* c_k. This rule can be used to recommend c_k to those learners who have visited c_x, c_y and c_z. Moreover, the authors of (Rabatel et al., 2013) add *context awareness* to the extraction of frequent sequences. In brief, they suggest finding frequent sequences in specific contexts. For the aim of this paper, we can define the context as the prior knowledge (or/and competencies) of learners. For instance, it is possible to locate frequent sequences for *expert java developers*, *novice project managers* and so on. This approach requires the definition of rules able to assign individual learners to one or more contexts. During exploration, learners could receive suggestions like, for instance, *resource annotated with concept* c_k *could be useful for you* on the basis of: i) known contextualized frequent sequences, ii) contexts associated to them, and iii) concepts visited in the current session.

4 LEARNING DOMAINS AND SCALABILITY

One of the main advantages of the Social Semantic Web platform is that we may contextualise them for different types of communities acting in different environments and having different sizes. This characteristic is enabled by the numerous existing vocabularies covering different domains. For instance, if the community we would like to consider is composed by the employees of a Knowledge-Intensive Organization, we need to integrate vocabularies and ontologies for describing projects, competencies, roles, strategies, tasks, documents, training material and so on. Otherwise, if the community we would like to consider is composed by consumers related to the world of cultural heritage, we need to consider ontologies like CIDOC-CRM[9], Geonames[10], etc. Thus, if we change the domain, Semantic Web mechanisms allow us to change the vocabularies and ontologies but not the approach (SKOS-based) presented in Section 3.4.

Furthermore, the Social Semantic Web platform is highly and natively scalable. Both horizontal and vertical scalability can be considered. More in details, horizontal scalability occurs when more than one communities are considered. This case is illustrated in Fig. 4. A community can be repre-

[9]http://www.cidoc-crm.org
[10]http://www.geonames.org

sented by a set of SKOS concepts schemas, a set of persons and a set of vocabularies and ontologies modelling data (coming from software applications used in that community) which are relevant in a specific domain. The proposed approach and, in particular, `skos:relatedMatch`, `skos:broadMatch`, `skos:narrowMatch` properties can link SKOS concept schemas belonging to different communities and enable serendipitous learning process among different communities. Adding a new community is allowed also at run-time.

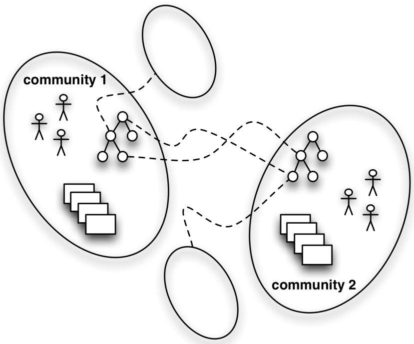

Figure 4: Horizontal scalability.

Vertical scalability is allowed by the capability of Semantic Web to add new information systems and, thus, new data at run-time.

Lastly, a third type of scalability may be considered: infrastructure scalability. This means the capability to handle different and distributed storage systems for ontologies and, in general, semantic data is guaranteed by the distributed nature of RDF.

5 EARLY EVALUATION, FUTURE WORKS AND FINAL REMARKS

The work proposes an approach to exploit the Social Semantic Web platform to support Serendipitous Learning. The SIOC framework and its *food chain* have been generalized in order to support multiple domains. Two interconnected ontology types have been introduced. The first one is used to describe relevant resources. The second one is used to classify and connect heterogeneous resources and it is mainly based on SKOS. Moreover, suitable methods for link and path discovery, leveraging on *classification ontologies*, have been proposed. The scalability of the proposed approach has been shown. An early partial evaluation has already been executed in the context of the experimentation of an integrated workplace learning system (developed in the context of another R&D Project by the same authors). More in details, we deployed *SMW+ (Semantic Media Wiki Plus)*[11] to allow users to interact with the ontology layers for a fixed time interval in order to experience and answer to a Likert-based questionnaire. In particular, 20 workers of CRMPA (Centre of Research in Pure and Applied Mathematics)[12], involved in four R&D Projects, were asked to use the deployed system for two months in order to support their project tasks. At the end of this period, the 20 workers are asked to answer the questionnaire consisting in 12 questions. Among these questions, the item Q10 asked workers to evaluate their serendipitous learning experience with the deployed system. In a scale from 1 (worst) to 5 (best), the *median* was 4, the *mode* was 5, the *variability* was 1.2 (for *range*) and 3 (for *iq range*). All these values refer to the item Q10. Of course, the executed experimentation is largely insufficient to evaluate the proposed approach but it has been performed in order to understand its potential usefulness. Thus, we have already planned to execute a complete experimentation in a larger community of users in the context of the SIRET Project (see Section 5), where we will set two groups (an experimental group and a control group) of learners (with the same objectives) and we will try to analyse the differences in the knowledge acquired in a group rather than in the other one. Discriminate the knowledge acquired by means of serendipitous processes will be one of the main challenges of the experimentation methodology. Additional experimentation phases will be executed to evaluate the algorithms proposed to construct and manage ontologies and to perform link discovery and context-dependent sequential pattern mining.

ACKNOWLEDGEMENTS

Partially supported by the Italian Ministry of University and Research under the PON 01_03024 SIRET, Recruiting and Training Integrated System, project approved by D.D. 721/Ric 2011, October 14 and started in 2011, November 1. Special thanks to the other partners involved in these activities: CRMPA, Centro di Ricerca in Matematica Pura e Applicata, Fisciano (SA), Italy and MOMA S.p.A., Baronissi (SA), Italy.

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Assistance for Learning Design Community
A Context-awareness and Pattern-based Approach

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Keywords: Learning Design, Design Process, Assistance, Context-awareness, Patterns, Pedagogical Design Scheme.

Abstract: Designing learning is a complex task. Researchers and teachers have proposed many methodological issues to deal with it. Despite valuable technological advantages of machine-readable outcomes, most of the time these proposals are too complex to use, limiting the expressiveness, the sharing and reuse of learning scenario by the teachers' community. Learning design processes support and guidance are often missing or insufficiently adaptable to the design context. Based on the needs of an association dealing with professional integration in charge with back-to-work programs named PARTAGE, we defined a design approach based on patterns and an editing tool to support the learning design activities to help the sharing of pedagogical scenarios inside the teachers' community of PARTAGE. In this work, we focus our attention on the assistance abilities of the editing tool, depending of its design context awareness. We realize a pilot study on this approach according to a participatory design approach with trainers of the association and the research team in charge with the study.

1 INTRODUCTION

According to Laurillard, teaching may be considered as a design science (Laurillard, 2012, p1). Learning Design is a complex task (Rohse and Anderson, 2006). The learning design research field produced a set of design process, methods and associated tools such as Instructional design models, the MISA Instructional Engineering Method (Paquette, 2004), learning design specifications like PALO, LDL or the IMS-LD learner activity-driven approach (Koper and Olivier, 2004).

Researchers in Technology Enhanced Learning (TEL) get increasing interest within approaches based on patterns. Patterns are potentially valuable tools for designing complex learning management systems. Design approaches based on patterns introduce a way to negotiate the new emergent roles of teachers and learners by, for instance, allowing the learner to assume a designer role, based on the instantiation (contextualization) of a pattern on a given learning situation (Rohse and Anserson, 2006). By example, learners or teachers may assume a designer role criticizing or refining a pattern solution as the context evolves on a learning situation. These approaches are immediately relevant to teachers as they present means by which the teaching community can participate in design. The knowledge and the know-how developed by the teacher is externalized, embodied in patterns sharable in a community that can critique and build its knowledge (Laurillard, 2012, p8). COLLAGE, a collaborative learning flow pattern (CLFP) editor (Hernández-Leo et al., 2006) proposes a visual pattern based design approach implementing learning scenarios in RELOAD. This approach is based on the IMS LD specification which enables the modeling of learning processes. The MDEduc project proposes a Pedagogical Patterns Editor for the design of learning scenario. This is a text editor using the formalism and the syntax of patterns. ScenEdit and the ISIS model support also a pattern based approach to design learning scenarios. Teachers can share and reuse practices with patterns as far as they could be expressed with a pedagogical oriented vocabulary and syntax.

Nevertheless, these approaches propose teachers to identify the best solution (pattern) among existing ones for their pedagogical needs according to a given pedagogical model, reflecting a specific pedagogical approach. We've named such models pedagogical design schemes (PDS).

Nevertheless, these approaches have some limitations. One of them is the lack of design assistance mechanisms (Villiot, 2007). According to

(Dufresne et al., 2003), two assistance levels could be defined : the first level is to provide users with an editing tool for designing a pedagogical scenario, the second one is to offer a support for design activity with such an editor. In a design context where instantiating patterns are emphasized, we introduce a third level of assistance, for helping the users to reuse existing patterns and to share new ones.

Thus, our main issue is to define a design approach based on the instantiation of shared patterns, by using an editing tool where the design activity benefits from contextualized assistance which takes into account user own design approach identified as pedagogical design scheme.

Our technical approach is in the scoop of Domain Specific Modeling. It allows designers (assisted by modeling experts if needed) to define their own Educational Modeling Language by specifying a domain-specific language and to use it for building their scenarios (El Kechaï and Choquet 2006). This approach enables the design of computational models (i.e. models interpretable by a computer) which could be enacted by compliant systems.

The work we relate here was primarily based on the needs expressed by PARTAGE, an association dealing with professional integration in charge with back-to-work programs. Initially, the persons in charge of this association wanted to produce computerized pedagogical materials in order to facilitate capitalization, reuse and adaptation. Then, they have stressed the need of a tool to support their design sessions in order to produce scenarios more adapted to their heterogeneous public. Finally, considering the important turnover of their training staff, they wanted to capitalize the training know-how of experimented teachers, to be able to share it with novices ones and to provide assistance when trainers are involved in the design of a learning scenario. We worked with trainers of this association within an iterative participatory design methodology, in order to fit better with their needs. The results of this pilot study consists in (1) a design approach based on patterns (Clayer et al., 2013), (2) an editing tool which allows different pedagogical design scheme models, (3) a way of sharing pedagogical scenarios in a community or, more exactly, patterns which could be instantiated by any member of a community, for his/her own design, and (4) an assistance system that guides teachers during the learning design activity, according to their pedagogical design scheme.

In this paper, we focus on the characterization of the assistance system we have developed for PARTAGE (section 3) and we relate the first experimental uses of the editor by trainers of the association (section 4) in a pilot study. We conclude this paper by some considerations on the possibility to generalize the assistance approach we have defined (section 5). The next section of this paper presents the relevant notions of patterns, user assistance, context-awareness and pedagogical design schemes.

2 ASSISTANCE FOR LEARNING DESIGN

2.1 Patterns

A pattern is a semi-structured description of an expert's method for solving a recurrent problem which includes a description of the problem itself and the context in which the method is suitable (Mor and Winters, 2007). Patterns are "good solutions" to deal with complexity characterizing the educational field (Rohse and Anderson, 2006). This formalism offers the teacher an opportunity to externalize his knowledge (Goodyear, 2005) and can be formally expressed. A pattern is defined by three properties: a problem, the context of this problem and a solution. Each pattern captures the best way to solve a problem in a particular context. Patterns guide rather than prescribe (Rohse and Anderson, 2006). A pattern language describes the relations between patterns (associated, composed of…) that capture the whole design process and can guide the designer through step-by-step design guidelines.

According to the Domain Specific Model approach we have adopted for this research work, a meta-model of patterns has been defined to describe the pattern language and a set of patterns has been elaborated and presented in (Clayer et al., 2013).

2.2 User Assistance

(Rech et al., 2007) defines several dimensions for an assistance system:

- the presentation of assistance to the user;
- the way to define assistance algorithms.

Each assistance system could reify the assistance by different kinds of actions:

- The *adaptation* (Andresen and Gronau, 2005) is defined as a characteristic for a system to identify the capacity of this system to modify its structure according to situations or events.

- The *retro action* (Dufresne et al., 2003) improves the activity by highlighting or focusing on the elements to complete.
- The *advice* suggests process or task to realize in order to reach user's goals.
- The *constraint* ensures consistency with the element affected by this constraint.

The user's task assistance we present in this paper implements these four kinds of actions, with a particular focus on the reuse of the pedagogical elements and scenarios.

2.3 Context Awareness

Context-aware systems (Bardram, 2005) are well-suited to support adequately the learning design activity of teachers and trainers. An assistance system uses context to provide information and/or services to the user, where relevancy depends on the user's task (Dey and Abowd, 2000). User's task refers to the interaction between the system and the user during the design session.

Thus, we have proposed a learning design adaptive process based on the user's design context and the design activity. It addresses an automatic user modeling approach where the user's model is defined during a tool design activity session from user's characteristics (user profile, design session's context, and user skills) and its interaction with the system.

User models and user modeling are key elements for personalizing interaction. User modeling is motivated by differences in individual user's needs and characteristics and heterogeneity between different groups of people (Razmerita et al., 2003). User's characteristics and interactions between the user and the system are relevant tracks to collect and will be used to help teachers/trainers to manage their learning design activity.

2.4 Pedagogical Design Schemes

The characteristics of a learning scenario are mainly conditioned by the choice of the pedagogical approach and the learning strategy (Paquette, 2004). Commonly, communities of teachers could be identified by the same context of teaching: a class level, a learning domain, a pedagogical approach. More rarely is, for a community of teachers or trainers, the sharing of a particular pedagogical design scheme (PDS).

A pedagogical design scheme is the approach for designing a course, in our context, a learning scenario. A pedagogical design scheme is defined by an oriented graph of the pedagogical elements (e.g., in the context of IMS-LD, a role, an activity, a learning objective, etc.). The first pedagogical element defined by the designer is the root of the oriented graph and gives the orientation of the PDS. When practicing teachers design a learning scenario with the same design objective, the pedagogical design schemes could be different. For the same design problem, many pedagogical design schemes could exist. Some practitioners, depending on their experience or on the context of design, could start a design by defining resources of the scenario and then, in a second time, related activities and strategies. Some other designers will begin by describing objectives and intentions of the scenario first and associated activities and resources afterwards.

Early instructional design approaches have developed concepts for systematically designing instructional materials. The IMSL-LD specifications are based on a learner activity driven approach (Koper and Olivier, 2004). This kind of languages provides best practice guides driven by the efficiency of the modeling rather than pedagogical design schemes. Editors developed for these languages want usually to instrument the modeling activity guided by a given design approach, underlying implicitly the interfaces. Some authors identified pedagogical design schemes driven by strategies and intentions. This kind of schemes supports the design process in the ISIS model (Emin, 2010).

We think that, for tooling and supporting a design community of learning scenarios, one has to develop designs tools allowing different pedagogical designs schemes. Thus, we have developed such an editor and performed a pilot study with trainers of a same community of teaching for evaluating its usability.

3 ASSISTANCE IN DESIGN APPROACH

User designs pedagogical scenarios composed of pedagogical elements (*activity, learning strategy, objective, role, material resource, learning situation, etc.*) represented by patterns in our learning design approach. A simplified graphical description of a process pattern for the activity "Realize an individual evaluation/training" is proposed (Fig 1).

To support the user during his design activity, we define (1) a "designer context", e.g. a data structure for capitalizing the information on the designer's

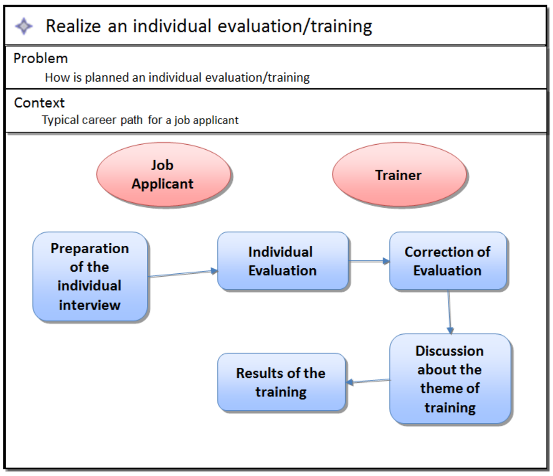

Figure 1: Simplified Graphical Form of a Pattern.

pedagogical practices and actions, (2) a task model to identify the current design activity in accordance with the pedagogical design scheme of the designer, and (3) an assistance process which performs a set of assistance actions adapted to the designer context and the current activity.

3.1 Designer Context

A "context" is a structured set of information that can be used to characterize the situation of an entity (a person, place or object) that is considered as relevant to the interaction between a user and an application, including the user and the application themselves (Dey and Abowd, 2000).

In our approach, we refer to *the context of a designer* to qualify the context of a person, a user (a teacher or trainer) in his learning design activity. This designer context may be characterized by three facets:

- **The User Profile** (Amato and Staraccia, 1999) is defined with the information based on the interaction with the system, user preferences and user knowledge. Examples of these data are: the level of adaptation expected in the tool (automatically, with the confirmation of the user, minimum adaptation), the login and password used to identify the user, etc. All of these data could be changed at any time by the designer.
- **The Design session's context** is the context created during one design session. Each designer context saves the review of all design session's contexts (one by effective session, and by user). This context is composed of :
  - **The Pedagogical context** qualifies learning strategies and objectives defined by the designer.
  - **The Institutional context** is a set of information on the constraints, rules and resources imposed or available to the designer by his/her institution (in this paper, the association PARTAGE).
  - **The Domain** gathers, by the help of keywords, the information concerning the concepts of the user learning domain.
  - **The Context of use** gathers information during the designing session in order to qualify the nature of the task: the Pedagogical Design Scheme and Assistance actions.
- **The User's Skills** are the skills the designer is supposed by the system to master, as far as he/she used the functionality of the tool (for example: "to reuse a pedagogical element" or "to link a role and an activity together").

User Profile is a static set of information filled by a form during the first session and/or actualized on designer's demand. Design session's context is updated by the assistance process during a design session. When a user creates a resource, this resource is capitalized in the Institutional context as a resource available inside the relative institution. User's Skills is the part of the context taking into account the user experience. It is updated depending the nature of the interaction and the user's actions.

3.2 Task Model of Design

Task models are useful for supporting the user during a session. With such a task model and by defining links between tasks and the interaction devices composing the user interface, an editor could provide context-sensitive, task-oriented support to the designer (Pangoli and Paternò, 1995). Considering our objective, we have chosen to adapt the user task model defined in (Paternò, 2001), as it is centered on the task of the user.

We have defined two levels in the task model:

- The first level is the pedagogical design scheme itself. The pedagogical design scheme is updated after each task performed by the user.
- The second level is a tree of tasks. The tree of tasks is associated with a category of pedagogical elements and represents the tasks that the user is able to perform during a design session with these pedagogical elements (Fig.2).

3.3 Assistance Actions

As described above, the assistance can lead on

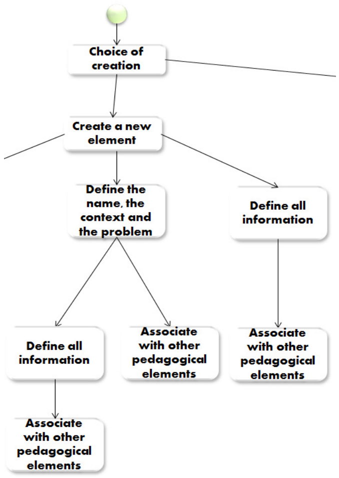

Figure 2: Partial Task-Model for the creation of an element.

many kinds of actions (message of the system, guidance, adaptation…) (Dufresne et al., 2003). We have implemented four kinds of assistance actions in the assistance system:

- **Guiding:** The system supports the user with a guide of practices, adapted to the current design activity. The textual information relative to the current action is highlighted and changes according to the next user's action. This assistance should enable the appropriation by the designer of the best practices of design regarding its Pedagogical Design Scheme.
- **Consistency ensuring:** The system informs the user if the current user's action has an impact on the coherence of the scenario. For example, if an activity is defined with a given resource, and if this resource is already registered in the system, the system informs the user that the resource exists and it can be added automatically to the current design model. This assistance ensures that the pedagogical scenario is consistent (by checking on the proprieties of elements, the meaning of combinations or associations of elements) at the end of the design session.
- **Action anticipating:** The system anticipates the next design action on the basis of the model-task, the pedagogical design scheme and the current design activity. Firstly, the pedagogical design scheme is used to identify the type of pedagogical element currently handled by the designer; then the task model associated to this pedagogical element is used to identify the current design activity. For example, if the user has created many activities, added a material resource and associated this resource to an activity according to its definition, the system verifies and creates all resources required by an activity (referenced in the definition of an activity).

  Retroaction providing: The system uses the pedagogical design scheme and the current design activity to verify and modify each pedagogical elements of the current design activity. For example, if the user changes the prerequisites of an activity, then the system has to change the associated pedagogical elements.

The assistance actions are implemented by a rule-based system. A set of rules is defined for each design activity and inferred among a forward chaining, fired by user/system interaction events.

3.4 Assistance Process

We have defined the assistance process as an iterative cycle of four steps, as the one synthesized in (Lopisteguy et al., 2012).

- Step 1 "Collect information". The system collects information: the pedagogical design scheme of the session as well as the information describing the current user action and the designer context.
- Step 2 "Qualification". The system identifies as the current design activity, the last activity started in the pedagogical design scheme. The context of the designer is updated with the information collected.
- Step 3 "Diagnostic". The system searches in task-model the current activity and selects the set of rules associated. This set of rules is composed by rules for each type of assistance actions. The rules are contextualized (variables are valued with the collected information). Then, the current design session's context is checked in order to ensure the consistency. By analyzing the task model, the system selects the actions to anticipate. The guide is selected or updated regarding the current activity. The set of design session's contexts is used to provide retroactions. The user's skills and the level of assistance are updated in the user profile and used to fix the level of selected assistance actions. Finally, the system elicits the action(s) associated to the best contextualized rule(s) to be applied.
- Step 4 "Adjustment". The system applies the qualified assistance actions and, if necessary, informs the designer of the assistance applied (example of message: "A new resource has been

added to the scenario").

This assistance process is active along the whole design process (Clayer et al., 2013). We will highlight this process in the next section, with a first test out of an editor implementing this assistance process.

4 PILOT STUDY

4.1 Description of the Pilot Study

We realize a pilot study with the professional trainers of PARTAGE. Three main characteristics concern this association:

- PARTAGE provides trainings essentially based on formative evaluations supported by classical pedagogical resources and methods (teacher-learner based strategy).
- Pedagogical resources are not always well-adapted to the public. Learners are adults unused to be trained and being at a loss with classical paper-based aid. Moreover, they often have difficulties with the basics knowledge of reading and writing or oral expression.
- The association faces many changes within its trainers staff. This turnover doesn't facilitate the reuse and the sharing of the teaching know-how.

This pilot study takes place in a design participatory approach (Schuler and Namioka, 1993). Ten trainers of the association took part in this pilot study. The pilot study has been conducted during three iterations which have each occurred during a period of two or three weeks the last two years.

In a first step, after having observed and analyzed the practice of the association, we have proposed some patterns (Clayer et al., 2013) co-constructed with the trainers.

In a second step, during one of these sessions of participatory design, we have assigned the trainers with a new learning situation to design. Each of them has designed a complete scenario of the learning situation, creating by the way many pedagogical elements. This was the opportunity for us to identify and then to model different Pedagogical Design Schemes.

We have then developed an editor, taking into account the PDS and the patterns previously formalized, and implementing the assistance process we have defined.

4.2 An Editing Tool

The editor is generated into the EMF-GMF framework (Steinberg et al., 2008). EMF-GMF framework supports fast update cycles of development for tools (Krogmann and Becker, 2007). The interface of the tool allows the designer to visualize the pedagogical elements he/she instantiates in a graphical view of the solution (Fig. 3-A). A toolbox provides the design primitives (pedagogical elements: *objective, pedagogical strategy, material resource, human resource, activity, learning situation*) (Fig. 3-B). Finally, a visual description for the information concerning the pedagogical element is accessible through the tab property (Fig. 3-C).

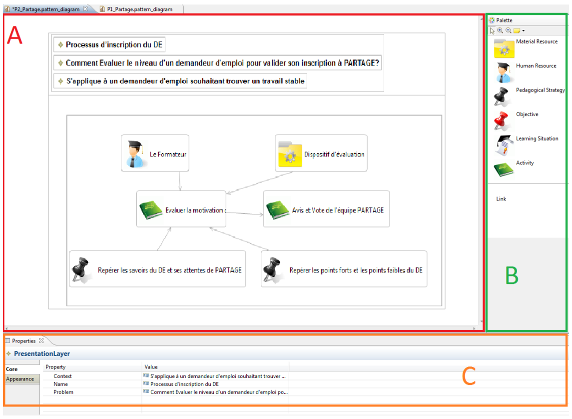

Figure 3: The interface of editing tool.

4.3 Test out of the Assistance

In a third step we have proposed to two trainers to test out the editor. After a short introduction on how using the interface, we asked them to design a pedagogical scenario for a real training session to test the feasibility of our methodology. They design together the pedagogical scenario of a training session on "the risks related to population ageing". We present here the scenario of this design session to explain how the design assistance tool system works for supporting the user task.

The trainers decide to define first the pedagogical strategy. They select the pedagogical element "Strategy". The system collects this element (step 1 of the assistance process). The system identifies the current task "create strategy" and it adds it to the pedagogical design scheme model. A new strategy is added in the pedagogical context of the session context (step 2). The system selects the set of rules for the task "Create a new element" and contextualizes it. For each rule of the set, the system changes the default type of pedagogical element by "Strategy" (step 3). The system tries to apply contextualized rules but no condition on a rule is validated (step 4).

Then trainers decide to add a new element to the scenario instead of reusing an existing one. The system collects the user action (step 1). The assistance system identifies the current activity as "Start new element: from: strategy" and adds the activity to the pedagogical design scheme model (step 2). The system selects the set of rules for the task "Start new element" and contextualizes it (step 3). The system is looking for rules to apply. Two rules are validated and applied. The propriety "context" of the element is initialized to the value of the "context of the scenario" (consistency ensuring). An assistance guide exists to describe the best practices to "create a new element" (step 4). The context information is filled and the guide appears (guiding) (Fig 4).

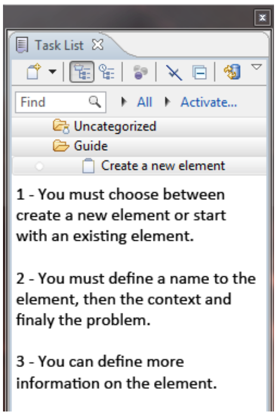

Figure 4: Guide appears on the left on the screen.

Trainers define the name of the strategy "raise general awareness of the ageing". The system collects the name (step 1) and identifies the current activity as "Define Name: from: strategy" (step 2). The system selects the set of rules associated to "Define Name" and contextualizes it (step 3). The system tries to apply the set of rules. Only one rule has the condition to be validated and applied: the same name for the same type of pedagogical element was used in a previous design session associated to an objective (step 4). This objective and the link between the objective and the strategy are created and the system informs the user with a message box (action anticipating).

At anytime, the user can change the assistance level to reduce the number of messages or deactivate the assistance system.

5 DISCUSSION AND CONCLUSIONS

We have been approached by PARTAGE, an association in charge with back-to work programs, over helping them to improve their learning design activities. Some trainers were involved with us in an iterative participatory design research approach. We have elaborated in a first time a design approach based on patterns and co-constructed with the trainers some patterns which embodie their teaching know-how. In a second time, we have studied with them the assistance process and proposed a context-awareness system to support the design activity, based on pedagogical design schemes and task models. At the end of the pilot study, trainers have reused existing patterns and designed new ones, describing a pedagogical scenario of a learning situation.

The design assistance approach we have proposed is based on a pattern design methodology and has been elaborated by studying a community of trainers involved in specific training needs. In such an approach, patterns are specific to the community and indeed it was our main goal: to embody the know-how of a community of practice in order to allow the sharing and the reuse inside it. Moreover, by allowing both the reuse and the creation of patterns during the design of a learning scenario, we focus the design *by* the reuse and *for* the reuse, strengthening by the way the designer's awareness of membership of a community of practice.

To facilitate the design and with the aim of enhancing the reuse, we have proposed a design assistance process which could be considered as an epiphyte system (Giroux, 1996), that is to say the assistance process is implemented independently of the design one, but synchronized with each step of it, by the help of handlers on interaction events. These events are basic and generic primitive design actions (as "create", "modify", "add", etc.) and the set of rules we have defined could be instantiated on any set of pedagogical elements, even if we think that the pedagogical elements we have defined here are very standardized (activity, learning objective, role, etc.). Indeed, we improve our approach with another community of practice, computer sciences teachers in our university.

We claim this design and assistance approach we have proposed could be applied with benefits when one wants to (1) capitalize the know-how of an existing teaching community of practice, (2) reinforce the identity of such a community, (3) enhance the productivity of its members, and/or improve the quality of learning designs.

For this, we continue to realize pilot studies on design sessions with PARTAGE and to improve the set of existing patterns and the assistance process; we have started a study with another community in our university, focusing here on the reuse of the assistance process; and we need also to collaborate with other learning communities to improve the assistance rule-based system on another set of pedagogical elements, enlarge the set of pedagogical design schemes we have identified, and better take into account the evolution of the experience of the designer.

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A Pedagogical Scenario Language for Virtual Learning Environment based on UML Meta-model
Application to Blood Analysis Instrument

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Keywords: Intelligent Tutoring System, Virtual Environment, Generic, PedagoGical Scenario, Knowledge Base, Learning, Training.

Abstract: Training to learn the use and maintenance of biomedical devices have various constraints. In order to complete these trainings, we proposed to use virtual reality based on pedagogical scenarios and Intelligent Tutoring Systems (ITS). In this paper, we first established the existing pedagogical scenario models and ITS. Subsequently we presented our proposal of a formal model based on the concept of learning organization by extension of UML in order to describribe some pedagogical scenario and ITS. The use of this model is illustrated by an application of a virtual biomedical analyzer with the aim of learning the technical procedures of the device. Finally, we performed two experiments in order to verify the efficiency of virtual reality training.

1 INTRODUCTION

In the biomedical domain, the traditional training method consists of several learners in a classroom with a live instructor manipulate the device alternately: method one-to-many which is known to be irrelevant (Bloom, 1956; Bloom, 1984) This is the case for the STA-R® instrument (Figure 1) produced by STAGO who sponsored this work. Unfortunately there are several constraints inherent in this training method.

Figure 1: Picture of the biomedical analyzer STA-R®.

First, there is always a potential biohazard while dealing with biological fluids. Second, learners have to use reagents to prepare the blood tests, which increase the cost and variability of the learning sessions. In some cases, the biomedical instrument is transported to the site of the learning session, which could damage it and again can impact the cost. Sometimes, the learning session takes place in the customer's site; therefore the instrument cannot be available for training. Finally the use of diagnostic device is time-consuming for the learner because of inherent time needed during the analytical.

Considering the above, the use of informatics tools for biomedical training sounds interesting. The objective of this training is to manipulate the device according to well-defined procedures. However the successful completion of these procedures requires biology knowledge. A learning strategy like "learning while doing" is relevant : the learner has to manipulate the device. Therefore, we consider that virtual reality is a major contribution in this context. Virtual reality has proven to be efficient to solve those kinds of issues (Mikropoulos and Natsis, 2010; Okutsu et al., 2012). Pedagogical situation using virtual reality are called Virtual Learning Environment (VLE).

However in a lot of professional environment and particularly in biomedical sector, there is a lot of staff turnover. It became then pretty common for employee to not go through the classical learning sessions. The objective of this paper is to propose a solution to implement the pedagogical strategy of the trainer inside the VLE so that the learners could train without having the initial training. Moreover, each individual learner can have its own basal level. So, our VLE have to be able to adapt itself to the learner in order to be really efficient. In medical field, some work were conducted like an application for medical problem-based learning (Suebnukarn and Haddawy, 2007).

This paper is organized in five sections. In section 2 we determined the existing solutions in the context of pedagogical scenarios and ITS. In section 3 we proposed our model based on a definition of a language for a pedagogical scenario (Koper, 2001). The ultimate goal for STAGO was to make an application based on the biomedical devices: VIRTUALANALYZER, presented in section 4 and we also conducted two experiments to verify the efficiency of virtual reality training. Finally, we concluded, in section 5, by listing the characteristics of our model that needed a further improvement and detailed the terms of an incoming experiment.

2 RELATED WORK

We focus on the acquisition of declarative and procedural knowledge on complex systems (many types of heterogeneous elements) in virtual reality. In this field, the most popular and representative tutor is STEVE (Rickel and Johnson, 1998), an animated pedagogical agent. STEVE belongs to the ITS field. Classically, ITS are structured on four models : domain, pedagogical, learner and interface (Wenger, 1987). One of the classic problems in ITS is to provide a generic language to describe domain knowledge. In our case, this knowledge is complex and from a high level of expertise. We have already proposed a meta-model MASCARET (based on SYSML, an UML extension) in order to acquire the system specifications to learn, directly from the conception(Querrec et al., 2013). This method allows us to generate the domain model and execute it in the virtual environment. It is not conceivable to rewrite this knowledge in the domain model, so it will be directly imported. Similarly, these specifications will directly lead to the generation of the virtual environment. A second problem in ITS is the link between the rules governing the pedagogical behavior of the tutor and the pedagogical course of training. Under the training procedures on complex systems, work has already proposed learning scenarios templates (explanation of the system and subsystem, explanation and organization of the procedures, repetition more or less guided). In our more specific context, learning scenarios have already been defined, it is therefore necessary to import it. In this paper, we propose a model to explain this pedagogical scenario in the pedagogical model related to the domain knowledge.

2.1 ITS

Our work belongs to ITS field. Classically ITS are structured around four modules:

- Domain : knowledge on the job to learn
- Pedagogical : knowledge on the pedagogical strategies
- Learner : knowledge representation of the learner. Very often, this knowledge is a subset of the domain knowledge where the learner had access.
- Interface : knowledge representation that the tutor may have on the actions that the learner achieves and the actions that the tutor can make in return.

This paper focuses exclusively on the pedagogical and domain models. Work on these models aim to make them generic, adaptative and individual (hence the link with the learner model). In the ITS domain, many research works were made during the past few years: some projects aimed at developing the generic part of ITS (Sanchez and Imbert, 2007; Shi and Lu, 2006; Sorensen and Ramachandran, 2007). Some projects aim at individualizing the simulation for each learner. This could be done for example through emotional agents (Ailiya et al., 2010) or by Hollnagel classification (El-Kechai and Desprès, 2007). At lower scale, some have highlighted the adaptability characteristic of ITS (Dos Santos and Osorio, 2004).

Typically, these models are defined from cognitive architectures like STEVE which is based on SOAR[1], or CTAT (Koedinger and Heffernan, 2003) which is based on ACT-R (Adaptive Control of Thought-Rational). Knowledge expressed in this system is defined as a set of rules like in ANDES (Vanlehn et al., 2005). In this context we have already proposed PEGASE which is based on the four classical models (domain, learner, pedagogical, inteface) (Woolf, 1992). PEGASE also contains an error model and a definition of the pedagogical model (usable independently of the exercise to do) in order to generalize it. One last important part of PEGASE is its adaptability, allowed by the auto-modification of the pedagogical model. PEGASE proposes a pedagogical model based on a hierarchical classifier system. This system organizes knowledge while taking the abstraction of the data involved into account. It structures knowledge according to three levels, from rules based on abstract knowledge of educational methods (the pedagogical approach), to the rules based on concrete knowledge

[1] http://sitemaker.umich.edu/soar/home

of virtual reality (pedagogical techniques), via an intermediary level (pedagogical attributes).

A major difficulty in the design of these models is writing these rules. For this there are three technical :

- Authoring tools like in CTAT (Koedinger et al., 2004), but can not be as generic as desired due to the proposed interfaces.
- Model-tracing which observe the actions of experts to build the domain model.
- Meta-model definition like the KBT-MM model of Murray (Murray et al., 2003) which has however a too high level of abstraction.

From this meta-model, Murray proposed a specialization called EON. Knowledge is then defined using ontologies. Many researches focused on some languages to describe the ontologies, like Resource Description Framework (RDF) or Web Ontology Language (OWL). The major problem of theses languages is that they do not allow to describe the dynamics of the situation when we precisely needed it to teach how works the instrument. We are interested in this approach but at an intermediate level compared to KBT-MM. Indeed, we propose a model in the context of learning procedures (handling, maintenance and diagnostic) on complex systems (industrial). Moreover, these systems are so complex that it is not possible to rewrite the system specifications (for the knowledge base or for the conception of the virtual environment).

MASCARET is an extension of the meta-model SYSML. It enables to describe the system structure by blocks, attributes and compositions from SYSML. The reactive behaviors of the system elements are described by state machines and the domain procedure are described by activities. MASCARET is a kind of SYSML interpreter for virtual reality and provides an operational semantic for every element of the meta-model. This enables to make the knowledge explicit for the agents during the simulation and to automatically execute the system entities behaviors. As we said in section 1, on this kind of system, work on the training structuring has already been done and it is therefore appropriate to incorporate the pedagogical scenario knowledge in the pedagogical model.

2.2 Pedagogical Scenario

Prior to 2000, teaching scenarios were based primarily on documentary approaches like *Learning Object Metadata*[2] (LOM) or *Sharable Content Object Reference Model*[3] (SCORM). From the 2000s Koper (Koper, 2001) initiated the use of educational modeling languages like *Educational Modeling Language* (EML). The main feature of EML is, that unlike documentary approaches, EML focus on the description of activities and not on educational resources.

Afterwards, Koper (Koper et al., 2003) contributed to the IMS-Learning Design (IMS-LD) standard, based on EML. IMS-LD focused on the concept of learning unit as a base element of the description of the learning process. Indeed, in IMS-LD a scenario is considered as a series of educational activities. Each of these activities is described by a text or a set of documents explaining the purpose of the activity, the task to achieve, the instructions to be followed, etc.

However, IMS-LD has its own limitation, like this review of Ferraris (Ferraris et al., 2005) based on the lack of expressivity regarding the description of the interactions between users in collaborative tasks. These models from VLE do not fully meets our requirements, so we had to look more specifically the existing models in virtual reality for training.

In the literature we could identify several virtual reality models for training. The FORMID (FORMation Interactive Distance) (Guéraud et al., 2004) project focus on pedagogical scenario activities in which learners interact with an interactive pedagogical object. Another proposal is called GVT (Generic Virtual Training) and is intended for procedure learning. The disadvantages of FORMID and GVT are that they are not generic, they are not reusable and there is no distinction between the activity scenario for the procedures of the environment and the pedagogical scenario.

Marion (Marion et al., 2009) proposed a model of a pedagogical scenario called POSEIDON, which aims to be directly reusable in different environments. POSEIDON covers various points like: educational objectives, prerequisites, education activities, education organizations and environments. We have decided to base our own pedagogical scenario model on POSEIDON because of this generic side. However the negative point of POSEIDON is its lack of link with an ITS. Our goal is to create this link so that the ITS can use the pedagogical scenario knowledge to reason.

3 MODEL

Classically, a pedagogical scenario is composed of pedagogical objectives and prerequisites, pedagogical organization (set of roles), pedagogical activities and an environment (Koper, 2001). Following that definition, we considered that the trainer activity is a domain activity just like any other. Thereby we could

[2] http://www.lom-fr.fr

[3] http://www.scorm.com

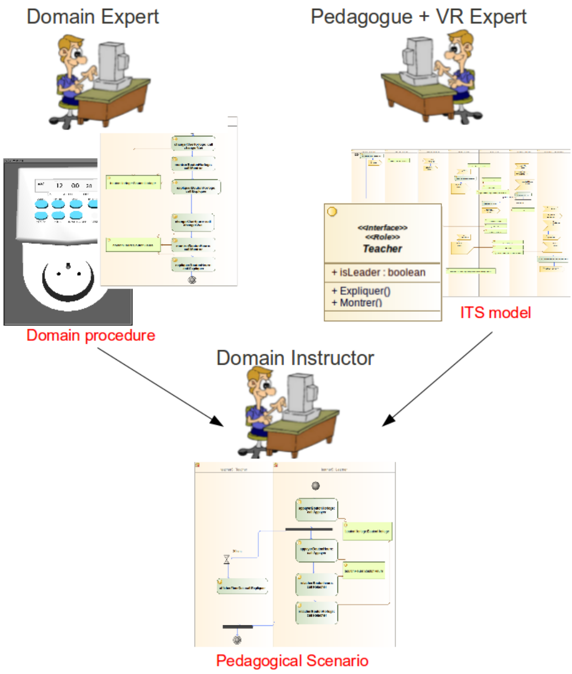

Figure 2: Workflow for application conception.

propose a formal model of the concept of a pedagogical scenario by extended UML. A pedagogical organization is considered like collaboration composed of Roles. A role is the UML concept of Interface. This means that a role lists a set of services without actually providing an implementation. The agent (artificial or human) who will play this role will propose its own implementation. Within this pedagogical organization, the role takes part to the pedagogical scenario as an activity arranging the pedagogical actions which could modify the virtual environment (composed of the system or the pedagogical resources). These concepts enable to create a pedagogical scenario and its development is now presented.

3.1 Workflow

In order to achieve a complete virtual reality training application (application, ITS, scenario), several people of various fields must participate. The picture 2 summarizes all the contributors described in this section.

First, an educationalist instructor assisted by a virtual reality expert defines the ITS model. Indeed, his instructor qualities enable him to define the best pedagogical strategies for the ITS, and the virtual reality expert knowledge allows to implement the pedagogical actions specific to virtual reality (set an entity in transparence, switch the point of view,...) The knowledge is and must be generic. They are described and implemented only one time and are reused for all pedagogical scenarios in all kind of fields. Second, another contributor must participate to the application development: the application domain expert who describes the entire domain model. The expert knowledge is centered on the field on which the application is based on. Finally, the domain teacher imports the ITS model, described by the educationalist instructor, and the domain model, described by the domain expert, in order to produce some pedagogical scenarios. This three step development enables to separate the pedagogical scenario conception and the system conception. Thereby, our pedagogical scenario model is generic and can be applied to other instruments and in other fields.

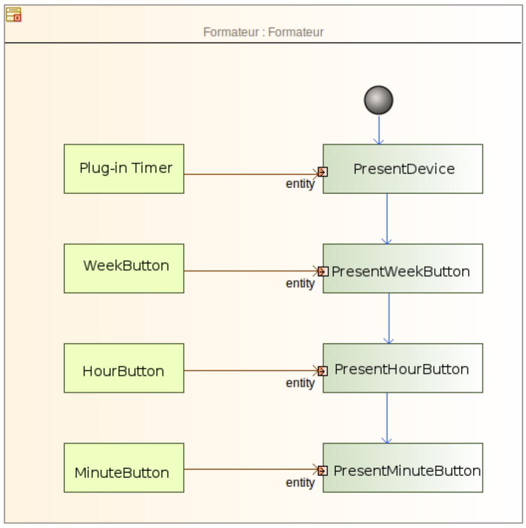

Figure 3: UML model of pedagogical scenario for system knowledge acquisition.

3.2 Pedagogical Scenario and ITS

Thus, the trainer could describe some pedagogical scenarios to learn from the system. This can be of two types: for knowledge acquisition or for procedure acquisition (use, maintenance and diagnostic). Based on an example of a plug-in timer application, we can present a pedagogical scenario for knowledge acquisition (Figure 3) including a trainer role who is responsible for presenting the plug-in timer and each of its buttons (Figure 4).

The “present” operation could be defined by the educationalist instructor in this manner:

- set all the entities in transparence except for the one to present
- change the point of view on the entity to present

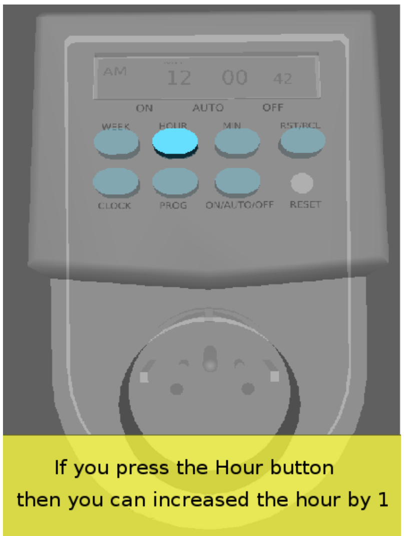

Figure 4: Picture of a plug-in timer in the virtual environment with the “present“ operation

- display the annotation from the domain model on the entity to present

So, the trainer should rely on this pedagogy and the domain model in order to create his pedagogical scenario. We could also describe some pedagogical scenarios for procedure acquisition: for example the teacher role presents the procedure and the learner role has to carry out the domain procedure.

Moreover, we could describe ITS behaviors in the same manner as the pedagogical scenarios described previously. This kind of modelisation ensures a high modularity of the system, which enables to create ITS behaviors more or less complex. For example, in picture 5, the trainer described the learner role which had to carry out a procedure of setting time of the plug-in timer. The teacher role monitors the environment, highlight the learner errors and perform an “undo“ on the current action (back to the previous state). The advantage is that the trainer can easily remove or add some actions, making our system very modular.

In the same way, we could create another application: VIRTUALANALYZER which is applied to our biomedical training problematic.

4 APPLICATION

The proposed model has been applied to the problem of training presented in section 1 in order to realize a virtual reality application for STAGO.

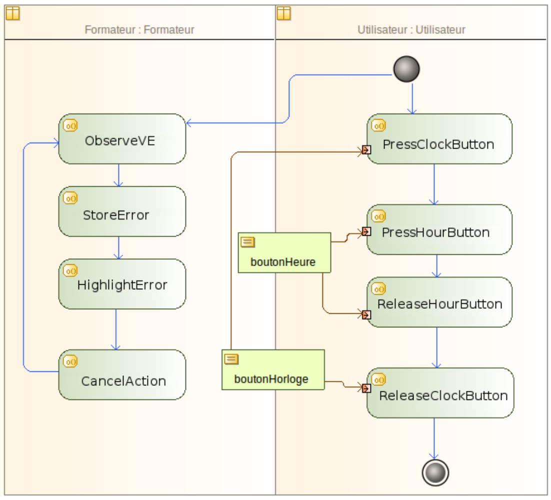

Figure 5: UML model of a ITS behavior

4.1 Virtual Environment

While looking for replicating the real STA-R® in a virtual environment, we made a virtual reality application with the instrument in a 3D environment and the control software modeled on ANDROID (Figure 6).

Figure 6: Virtual STA-R® application.

The environment includes a pre-operative blood work procedure. This procedure is composed of 125 basic actions and is coupled with a simple ITS behav-

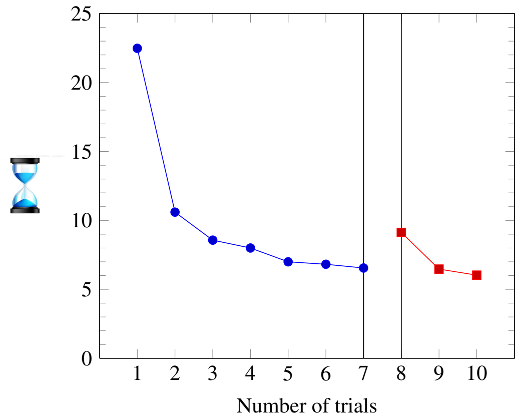

Figure 7: Learning curve: total time.

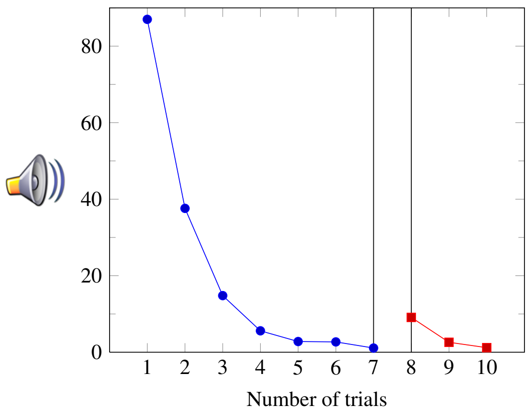

Figure 8: Learning curve: instructions.

ior: vocal assistance and blocking wrong actions. In order to verify the efficiency of virtual reality training, we performed two experiments. The first one aimed at verifying the procedure learning with 12 computer science students during two days. The second experiments goal was to verify the knowledge transfer on a real STA-R® with 58 biology students during ten days.

4.2 Experiments

4.2.1 Learning

First, the learners had to perform seven times the procedure described previously. After a week time, the learners came back to complete the second session of the experiment: they had to do three times the same procedure. In order to evaluate the learning procedure we collected behavioral data: total time of the procedure achievement, number of audio instructions consultation, number of wrong actions (Figure 7 and 8).

The total time of the procedure achievement and the number of audio instructions consultation decreased over repetitions. After seven days, the learners partially consulted the instructions only during the first try, and then their performance became similar to the latest ones of the first session. This is a typical learning curve. Thereby, this study confirmed the usability of VIRTUALANALYZER for learning procedure. However, a large number of try would be necessary to obtain a stabilization of performance and a lower number on instruction consultation at the 8th try, certifying the perfect acquisition of the procedure and its storage in long-term memory. Learning by using a virtual environment is favorable only if the skills acquired through this device can be used in a real situation. We attempted to verify this assumption in the following experiment.

Table 1: Results of the knowledge transfer experiment.

	Traditional	Virtual	Control
Achievement	100%	100	72%
SOS	0.2	0.7	3.1
Interventions	1.4	2.3	3.9
Consultations	9.5	1.9	48.7
Total time	19'48"	30'02"	39'09"

4.2.2 Knowledge Transfer

This experiment aimed to verify the knowledge transfer on a real STA-R® with 58 biology students. The students were divided into three groups: control, traditional teaching and virtual teaching. Each of these groups had a theoretical training on STAGO, hemostasis, biological tests and the instrument during one hour. The traditional group had a classical training provided by a trainer from STAGO (six learners for one instrument) and the virtual group had a training with VIRTUALANALYZER (one computer for each learner): each group trained for two hours while the control group had no training. Thereafter, each learner had to individually perform the entire procedure on the real STA-R®.

In order to evaluate the transfer procedure, we collected some data: procedure achievement, number of paper document consultations, number of technician interventions, number of technician call for help and total time (Table 1).

This experiment showed no significant differences between the data of the traditional method and the virtual method, except for the total time. This difference can be explained by several ways: our android interface is very different from the real interface of the STA-R® and the learners have no notion of time of the working instrument. We hope to reduce this time to a value close to the traditional one, by modifying how to provide some information in our application. The knowledge acquired with our virtual environment is transferable in a real STA-R®.

5 CONCLUSION AND FUTURE WORKS

STAGO wanted to use virtual reality and virtual environments for training for their biomedical diagnostic devices. Thereby, we proposed a training application for a STAGO instrument called VIRTUALANALYZER. This enabled us to verify the quality of the learning during a training based on this application and also to check if the knowledge is transferable in a real environment. Therefore, our work met the objectives defined by STAGO. However, the conducted experiment did not enable to verify the contribution of our model on the learning. Indeed, the experiments are based on the application rather than a complex ITS behavior. This is why we would like to evaluate, in the future, the contribution of the ITS with a complex behavior (like the PEGASE one) on the application VIRTUALANALYZER. We also pointed out that the language ergonomic for describing the pedagogical scenarios is not intuitive for the trainer. Although the interface is graphical and formalized, the fact that it relies on UML concepts does not help the ergonomic and does not facilitate its use by domain trainers. Finally, the long-term goal for STAGO would be to deploy this work to their whole range of instruments.

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Information System Support for Quality Management Applying European Standards and Guidelines for Higher Education

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Keywords: Quality Management, Document Management, Service Network, Organizational Networks, Service Description, Structured Documents, Higher Education, Accreditation.

Abstract: Higher education institutions strive for high quality of study courses and programs. One important tool is the introduction of a well-defined quality management system (QMS) supported by information systems. Editing service and review documents with office tools is not sufficient; a consistent and coherent management of all data is needed in an environment for authors. Data analysis, especially target-performance comparisons, and flexible generation of a variety of web and PDF documents are required tasks. This paper investigates the problems of simple file solutions in more detail and derives general requirements for better software support. Based on the requirements we propose an object-oriented framework that is able to handle core tasks around structured documents associated with organizational networks on top of a relational database. Document and organizational structures can be adapted to serve special needs of institutions. The system follows the European standards and guidelines for quality assurance.

1 INTRODUCTION

Quality assurance and improvement of educational services are essential tasks for universities and other higher education institutions. A standard procedure to accomplish quality management is accreditation of study programs carried out by external organizations (see for instance the description of the U.S. system (Eaton, 2012) or the standards and guidelines of the European system (ENQA, 2009)). Internal structures and procedures should support and extend this external review process. This combination of internal and external procedures leads to substantial quality management systems (QMS) inside universities. For instance, German universities can get a so-called system accreditation (Akkreditierungsrat, 2013), if they have implemented an internal QMS with specified characteristics. Quality management systems are understood as a bundle of business processes and associated information at the organizational level. Besides quality data itself detailed master data about the study programs like module descriptions or objectives of study programs are needed, as a QMS can check quality only, if the expected achievements of modules and programs are known.

Higher education institutions worldwide accept in general QMS as a tool for quality assurance and improvement, although sometimes concerns exist in the introduction phase. A description of common misunderstandings, viewed from the perspective of an accreditation organization, can be found in (Romero, 2008).

Many universities store the additional information in document files and continue to use classic database-oriented applications for course management (containing basic course information like name, extent or semester and mainly used for course registration of students) concurrently. But editing QMS document files is not enough. It might be quite easy for everyone involved to write the documents using standard office applications supported by document templates and to generate PDF files for publication. In addition, a centralized directory system could be used to group the files, but this simple solution comes along with some critical problems. However, internal discussions at our university, mainly at our quality management board with experts from university administration and all faculties, illustrated the problems of redundancy and subsequent inconsistency of too many files in too many versions. Moreover, experiences of board members with external accreditation show that other higher education institutions have the same problems.

An example of a number based quality data item with many implications is a credit point attribute of a course module (e.g. following the European Credit Transfer System (ECTS)). It needs a consistent representation (summations should be correct or breakdowns to specification of attendance and learning times should add up correctly). It is used at several positions (module description, study and examination regulations) and quality analysis compares it with actual student workload data. Those kinds of data items should not be hidden in document files. It should be under application control, but still be integrated with text-based information about modules.

For these reasons an adequate information system for QMS should help to manage, to integrate and to utilize all documents and data. Exploiting these data for analysis of quality (like target-performance comparisons) and for further processing (like web site publishing or PDF generation using the additional text based information) would be very valuable. Furthermore, an integrated information system facilitates the uniform handling of quality management data and documents at the entire university.

This paper outlines basic features of QMS at universities and the correspondence to general quality management. It is based on the European standards and guidelines for quality assurance (ENQA, 2009), but could be used elsewhere, if similar tenets are applied. It investigates the problems of simple file solutions in more detail and derives general requirements for better software support resulting in a design proposal. The consequences for adequate software support are extremely comprehensive. It turns out that the major challenge for information system support of quality management at higher education institutions is to find a proper mixture of features known from document management and data management. After introducing related work we propose an object-oriented framework based on structured documents with associated organizational networks.

FINQUAS is an on-going project developing an implementation in order to proof the proposed concepts, based on the experience of our institution with program and system accreditation, but it is adaptable to special document and organizational structures of other universities. A first release of the system is available at our university supporting peer reviews.

2 OUTLINE OF UNIVERSITY QMS

In general, the established quality management practices at universities (for the European variant see (ENQA, 2009)) follow the basic scheme of PDCA (plan-do-check-act) cycles known from industrial management; see for instance (Deming, 2000). More sophisticated schemes are well known, too, and are applied as well. However, in the following we will only sketch and summarize major activities of quality management as preparation for the presentation of requirements and solution architecture. Specific institutions will vary appropriately these activity structures and associated information formats.

At the level of study programs the quality management activities can be summarized as follows:

- Planning defines the output by setting objectives like learning outcomes for study programs and key figures like a dropout quota of students (to take a simple example figure that does not take into account the influence of grades of incoming students) or professor/student ratio. Boards at institution or faculty level are usually responsible for setting the objectives.
- Doing refers to the implementation of the objectives. Higher education represents this as a program curriculum consisting of modules and their descriptions. In a broader sense it also comprehends the documentation about required technical (labs) and human resources with organizational structures. Precise descriptions are necessary as a base for quality assurance. The exact description structure can differ depending on the kind of study and university specialities. Besides the core teaching service, supporting processes and policies (examinations, notification of credit transfer, admissions, generation of certificates, course scheduling, etc.) have to be documented as well. A release process complements the development process of descriptions.
- Peer reviews are a standard practice for checking program quality (for instance as accreditation process). Based on documentation of the study program, on-site visitations and their domain knowledge, reviewers give a structured judgment. Checklists are a common way to support reviews. These lists are basically document templates filled out by reviewers. The written statements of reviewers can be

supplemented by comparisons of actual values with planned values for a set of key figures (for instance the dropout quota). The doing (implementation) should satisfy the objectives of the study program. Reviews and monitoring of key figures should be performed in periodic intervals. Before university boards approve reviews, usually answers on review conditions of persons in charge of a service (e.g. a program director) are considered in addition.
- Recommendations as review results lead to documented action plans and their execution in order to improve the quality of content and structure of study programs. Action plans have a common format as known from project management. Actions could be changes of program objectives or implementation. Traceability from review statements to actions and concerned learning services is an important demand.

PDCA cycles occur at other levels too. At a lower level quality assurance of modules is important as well. A module description has plan (objectives) and do (content, extent, examination) sections. Objectives of modules should be derived from objectives of the study program (which are derived from university or faculty objectives). Checking could be done by reviews or student evaluation. At a higher level the aggregation of programs to program families (at a department, faculty or school level) or of a whole university are under consideration. Objectives at a lower level should derive or extend from higher level.

3 REQUIREMENT ANALYSIS

The main subject matter of QMS is the quality of the educational services. An educational service can be divided into smaller units at the next lower level. Modules are usually the smallest considered unit. They are the basic building blocks of a study program, which can be perceived as a composed educational service. Closely related study programs build a service group indicated by organizational units like departments, faculties or schools. Finally, the entire university itself can be considered as an educational service as well. All educational services together build a service network connected by part-of relationships. The services have a common structure at all levels.

For each service a group of people is responsible, usually organized as a board (e.g. a departmental committee is responsible for a study program). Composition of services and responsible groups indicate the university organization from lecturers towards university executive board. Furthermore, all services have certain types of objectives and each service type has an individual set of attributes describing the special properties.

The checking activities of quality management (like peer reviews or monitoring reports) themselves have similar structures to educational services. Each activity has an assigned responsible group (e.g. a reviewer group is responsible for a peer review), has objectives and an individual set of attributes. Hence, these activities can be considered as services, too. The quality services are also part of the service network providing the interconnections with the educational services. The service network altogether describes the complete structural organization of a university. The two service types differentiate themselves by an emphasis on objectives (educational services) respectively review results (quality services).

Beyond these core attributes and relationships to supporting concepts, services have many individual attributes with textual and numerical descriptions as described above. The service description as a whole can be considered as a document, as a unit of work that is edited, printed, read, archived or moved to another point in the overall service network. Therefore a careful analysis of the functional requirements unveils many features known from document management.

- Document relationships: Documents (in the context of QMS actually service descriptions) have part-of relationships with other documents, for instance a module description could be part of one or more study programs. A review belongs to a study program.
- Version control: Study programs change over time and new improved versions which are only valid for a certain time period are continuously being released. New versions of documents could be valid only for new students, while older versions are still needed for current students. Versions no longer in use should be archived.
- Concurrent author access: Several authors might work concurrently on the same documents (e.g. a group of peer reviewers works on the same peer review at the same time). The time frame for work could be more than just minutes. It could be hours or longer.
- Flexible release workflow: New documents or documents with need for changes should be new versions in draft mode. Documents may only be

released after the approval of several boards or responsible individuals. Interim statements of reviewers and answers from document authors might be considered. Only after approval the documents can be applied. The workflow can differ from organization to organization. Therefore, an information system for quality management should be flexible and adjustable enough to satisfy the demands of various organizations.

- Flexible authorization: Some members of some boards are permitted to write on some documents, others not. Especially accessing of documents in draft mode should be disabled for not related groups or individuals.
- Auditing: It should be known who has changed what data, but not at tracing level (for instance at database operation level). The recording should be domain oriented and should show who called what application function and its parameter values.

Furthermore additional requirements exist which cannot be easily integrated into document management systems. These requirements can be achieved in a simpler fashion using solutions based on the standard relational database paradigm directly.

- Structured flat content: All documents regarding programs and their quality are highly structured and contain not only text but also numeric, enumeration, date and string data. The structure is usually simple, a linear sequence of sections and can contain lists of part information (e.g. a service with a list of objectives as part information).
- Extensible structure: It should be possible with small programming effort to add and to remove attributes from service documents in order to adapt to special needs.
- Data relationships: There are a lot of relationships between data at the detail level inside documents. For instance, learning outcomes of modules could be derived from learning outcomes of programs (sometimes documented additionally in matrix form and stored as a table sheet) or modules relate to lecturers.
- Data integrity: It is not possible to check data integrity with office applications for documents. While some input data are formatted text without any constraints, other data have number, date or enumeration types and require integrity checks, e.g. number of ECTS credits of a module, or the level of a learning outcome item described with help of the Bloom taxonomy (Kennedy et al., 2006). Constraint checking can get very complex, e.g. describing university boards responsible for study programs with a variety of roles (with minimal and maximal number of members) and member duration.
- Integration of other databases: Some information might be available in other databases or applications, for instance, master data from course management systems like weekly hours of a course, student progress or grading statistics.
- Data analysis: Obviously, quality management needs evaluation of data from status reports of documents for target-performance comparisons.
- Generation of varied mixed documents from partial files: It is quite easy to generate a PDF file from a text document, but sometime users like to generate a complete catalogue of module descriptions or a program curriculum (using partial data from module description).

4 RELATED WORK

An off-the-shelf document management system would support or could be customized to satisfy the first list of requirements (Päivärinta and Munkvold, 2005). But, they focus on documents as a whole (which could be extended only with attributes for meta information). The second list of requirements is specific to QMS and needs a special implementation. Furthermore it depends on the specific needs of each university. Data analysis could focus on just a few performance indicators, but could consist of a very detailed analysis. Convenient programming access to parts of documents is needed like query access to attributes in relational databases.

Content management systems are similar to document management systems and focus in addition on web publishing using XML and HTML (Päivärinta and Munkvold, 2005). Partial structure access is possible, but not fully integrated to persistence APIs of object-oriented programming languages.

Software support of QMS for industrial management is closely related to production planning and control (Gerber, 2008). For instance, test plans needs to be integrated into work plans or samples needs to be tested during production or at delivery of goods. Therefore, these systems cannot be easily reused for education services.

Management software for quality audits following ISO 19011 is another approach and part of the ISO 9000 (ISO, 2013) standard family of quality management. There are several software products for audit management available (easy to find by internet search with keywords like “quality audit software” or “QM software”; a scholarly overview is not yet available). They focus on any kind of audits (like reviews) on any kind of service activities. Adaption to university QMS would have to take into account the special data structures, processing and analysing at universities.

Although a lot of information about quality management at higher education institutions is available, there is only a small amount of scholarly literature about its software support. Reprotool (Pouyioutas et al., 2013) is a relational database application that manages course and program descriptions according to the European Credit Transfer System. The system facilitates the work of faculty members in a similar way as our system. An additional student module supports the recording and calculation of student workload. However, Reprotool is not focusing on quality audits and relationships to educational service descriptions.

PROCON (Dosbergs, 2011) is another system specialised on managing curriculum descriptions. (Pah et al., 2008) describe the system eUniv that uses a general groupware software to manage QMS-related documents and projects without specifying details. e-EdU-Quality (Moisil et al., 2007) is an extension on top of eUniv providing document templates, workflow, integration of external data like student performance indicators and student questionaires. General groupware solutions have a generic user interface not tailored for the needs of quality management at higher education institutions. It is furthermore difficult to integrate application oriented data analysis, because groupware systems are based on a generic data model.

Tools supporting course evaluation by providing questionnaires, for instance (Mediero et al., 2010) should be also part of a QMS, but are complementary to our object of investigation.

In the next section we describe an object-oriented framework that can be used for quality management with structured documents with relational access to parts of documents.

5 A FRAMEWORK BASED ON STRUCTURED DOCUMENTS AND NETWORKS

FINQUAS provides an object-oriented solution for the requirements above. It is based on a relational database management system accessed by an object-oriented persistence layer. Consequently, features known from content/document management systems have to be created on top, but the implementation can be reused for any kind of service description. FINQUAS is a framework that implements standard tasks of quality management, though it can be customized by simple inheritance for data structure, changed user interface descriptions, changed workflow configuration or new data analysis functions.

The basic idea is a concept of an abstract service related to generic components providing the general functions required for handling services. The management of concrete service types deals only with the special data. An advantage of this approach is that generic functions (mainly content/document management features) can be reused for all service types. Another advantage is that extensions with general database query access to special attributes of services and their general processing in the application program are still possible. In this respect we get structured documents: document objects with relational persistence access to parts (attributes and partial objects).

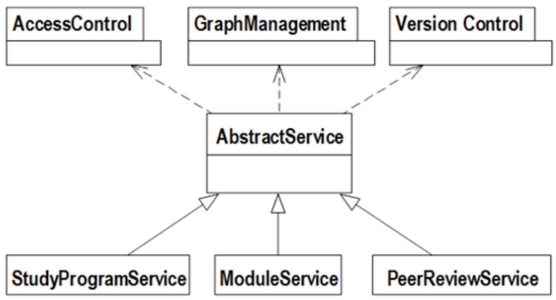

Figure 1: Related components of abstract and special service.

Figure 1 shows a simplified view of the abstract service concept. It explains how FINQUAS achieves its framework capability to adjust to diverse structure and organization details of higher education institutions. An `AbstractService` class provides the general features required in order to treat service documents. It represents the super class for concrete services like a study program, a module or a peer review of a program. The concrete service classes contain the actual data, texts and numbers of the service description. `AbstractService` is related to a couple of generic components as shown in the next figures and explained in the following paragraphs.

As described before, services could have relationships to other services. A graph structure helps to represent these relationships in a flexible way. Several kinds of relationships have to be considered. One example could be curricular relationships. A single module for instance, might belong to two programs. It could be a mandatory or an elective module. Organizational relationships, for instance between program and university, may exist. Peer reviews and study programs have a special control relationship representing quality assurance. Figure 2 shows a sample object diagram with university u1, programs p1 and p2, a module m1 and a peer review r1 (simplified view without adding levels like faculty).

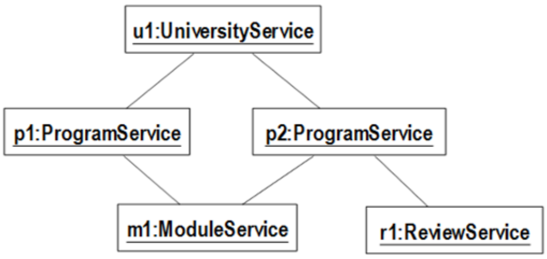

Figure 2: A sample service graph (or network).

To handle this task FINQUAS has a graph management component, illustrated in Figure 3. `AbstractService` inherits from a Node class. A `GraphProcessor` manages a set of nodes and edges (not shown in figure 3) between nodes.

A service has links to objectives that should be satisfied. Depending on the type of service, different types of objectives can be distinguished. FINQUAS uses subclasses of a general class for objectives to describe learning outcomes and planned values for key figures. Objectives should be coherent. This means in this context that objectives of superordinate services should be refined by services at lower levels. In order to comply with this basic principle of quality management the connections of objectives between higher and lower service level are captured at the definition time of services. These connections build a graph, too. Hence, graph management is reused for this task.

Each service has a group of people who are responsible for it. Figure 4 shows this relationship together with associated tasks. The configuration of a person group (at some university levels called board) could have to comply with complex rules. Group members might have a variety of roles. The number of instances for each role could be restricted to a specific range of values. The duration of memberships has to be considered, too. Additional representations are helpful for this kind of constraint processing. The group constraint processor in Figure 4 (class `GroupConstraintProcessor`) is a simplified depiction of this task.

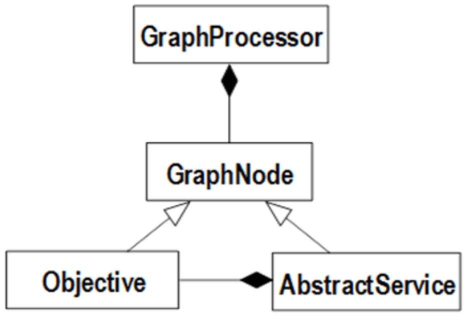

Figure 3: Graph management.

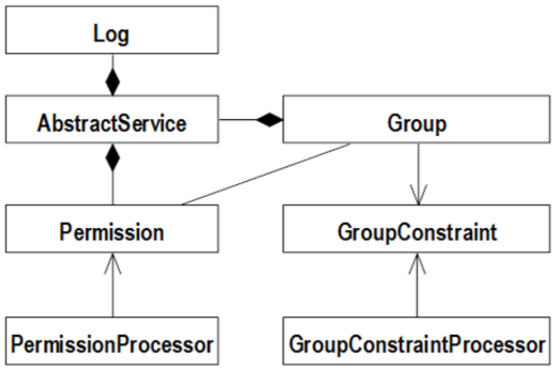

Figure 4: Authorization and group management.

A user who wants to perform an action on a service document needs an authorization from the system. The permissions depend mainly on some attributes of the service and of the user as well as on the group related to the considered service. In particular the role of the user, type of service, status (e.g. in draft mode only the authors have access) and action type are essential for permitting or denying access. Moreover, users belonging to a group associated with a superordinate service could have permissions on a service (depending on the organization service authors can have action rights for subservices, e.g. a member of the university executive board can have permissions to edit a subservice of the university like a program). Hence, a sophisticated and flexible processing of access control is necessary, as indicated in Figure 4 by the class `PermissionProcessor`.

When groups of people collaborate on service documents, auditing information is needed in order to annotate who has changed what. The system does not log information about the domain operation at the database operation layer. For this reason an auditing processor is implemented, which is directly related to the `AbstractService` class. It is implemented as a listener, which is triggered as soon as a service has been created or removed or any data of a service has been changed. The listener stores the modification date as well as the originator of the modification in the database. Besides the control aspects, the tracked auditing information supports the collaborative work on service documents by providing the information via the user interfaces to the collaborators.

Furthermore, our framework provides for the first software version a locking concept in order to ensure a consistent access on service documents. The locking concept is implemented by an access controller, which also belongs to the generic functions, provided by the `AbstractService` entity (see Figure 1). As soon as a user with accordant permissions begins to edit a service, the service will be locked. Thus, other users can't edit this service anymore as long as the locking author is working on the document. However, it is possible to read the service and see the current changes, made by the lock owner. Future versions of our system shall contain more sophisticated mechanisms in order to support synchronous collaboration of several authors on the same document. For the beginning we preferred the more conservative and proven approach of locking.

The lifecycle of a service is represented by a workflow or at least a service is involved in workflows from other services. For instance the lifecycle of a peer review service begins with the workflow state "DRAFT" and after passing several states it results in the state "DETERMINED" as soon as the accordant committee has approved the preceding steps. In order to enable a simple and flexible workflow concept for all services and their related documents, a workflow processor implemented as a state machine is needed, (see Figure 5, class `WorkflowProcessor`).

FINQUAS handles versions in a simple way at the level of an entire service. Creating a new version of a document triggers the copying of all service information. This is based on the observation that curriculum descriptions are changed only on a yearly base in average.

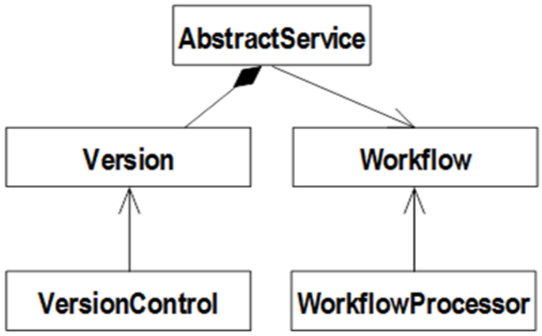

Figure 5: Version and workflow management.

6 CONCLUSIONS

The European Association for Quality Assurance in Higher Education requires as a standard information system support for QMS and demands "Institutions should ensure that they collect, analyse and use relevant information for the effective management of their programmes of study and other activities." (ENQA, 2009, p.7). In order to satisfy this standard with a complete and integrated system much effort is necessary. Complex requirements have to be considered and implemented. The definition of a QMS that fulfils the system accreditation criteria is already a challenging task in itself. But, since a lot of documentation has to be managed in a consistent and clearly arranged manner, it is important to have information system support. Furthermore, there are chances to exploit the knowledge for analysis of quality status of the institution and to generate web and PDF based information (which in addition should no longer be written redundantly).

Our project is very useful for us in several ways. It helped us to understand the requirements needed in order to get a reasonable quality management system. First experiences with users show that it facilitates the uniform handling of quality management at the entire university. It allows us to treat the information needed for QMS with an understandable and quickly accessible structure without redundancy.

The first release of FINQUAS supports peer reviews. According to the user feedback the main benefit for this task is that the quality managers get a clearly represented list of peer reviews and their current states. Communication with peer review groups is eased, since email addresses and mail templates for standard information are known by the system and available by one user interface click.

Next goals are monitoring reports for study programs (which we internally refer to as quality reports) and module descriptions. The developers could already proof the framework concept of the system. It is now simple to implement monitoring reports and module descriptions. Progress of programming is fast.

From a software-architecture point of view we found an interesting approach to work with extensible structured documents embedded into an organizational network of people. The network is quite flexible and can map any kind of hierarchical or matrix organization. Our first prototype implementation confirms our view of the architecture for a quality management information system. It is possible to extend the system to new service types with only a small effort.

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The Strategic Organization of the Observation in a TEL System
Studies and First Formalizations

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Keywords: Technology Enhanced Learning, Observation, Observation Strategy, Observation Needs, Observation Dashboard, Visualization of Indicators.

Abstract: The instructional designers may design learning sessions with tools offered by the Technology Enhanced Learning systems. Any learning situation is designed to follow specific learning objectives. Instructional designers examine the progress of these situations and evaluate the correlation between their deployment and the objectives through an observation activity. We present in this article theoretical and practical studies in order to understand the real needs of instructional designers in organizing their activity of observation. We also present the concept of Observation Strategy to answer the needs of instructional designers for organizing the observation of learning sessions deployed in the TEL systems.

1 INTRODUCTION

Our research activities focus on the observation of learning situations and the perception (such as visualization) of indicators when using a TEL system (*Technology Enhanced Learning system*). The observation is defined in (De Ketele, 1987) as a process to gather facts in order to analyze them. It is based on the processing of data collected during the deployment of learning situations within the TEL system.

We originally propose to consider the efficiency of an observation activity as related to the *a priori* definition and formalization of an *observation strategy*. This efficiency mainly relies on the relevance of various choices: the observation means implemented and/or used, the visual widgets selected for representing the calculated indicators, and so on.

This article aims at summarizing several objectives according to the following three points:

- To present and analyse the different studies we have done in order to explicit the needs and practices of instructional designers when specifying observations activities;
- To define and formalize the concept of observation strategy;
- To illustrate the proposition with a concrete example from past experiments about the observation in a TEL environment.

The organization of this paper was planned in such a way to meet these goals. After this introductory section, we focus on the observation in the TEL systems in order to show the actors concerned by this activity and their objectives related to the observation of learning situations. In the same section we present the context in which our research is carried out to show continuity with the research activity of our team and to summarize the goals of our work. In the next section, we discuss the theoretical and practical studies we have done to understand the real needs of instructional designers in terms of using pedagogical indicators. These two studies, with complementary objectives, respectively consist of a state of the art about the observation and perception of indicators and a field investigation to understand the needs of instructional designers. Once these needs are identified, we present the concept of observation strategy which is our answer for identified needs. The definition of this concept will be followed by its formalization as a meta-model. To better illustrate the concept introduced, we present a case study inspired by an experiment. The conceptualization of the case study will be in accordance with the proposed definition and the meta-model will be used to formalize this case study. To conclude, we present our current work.

2 CONTEXT

2.1 Observation in a TEL System

Any process delivering TEL learning situations should include a specific phase about observation and uses analysis in order to notify instructional designers of the quality of the deployed situation (Choquet and Iksal, 2007). By interpreting the results of an observation, teachers, or tutors, can guide the learning activity by trying to encompass the potential dysfunctions related to the learning scenario designed (Settouti and al., 2007). They can then introduce personalized support and provide educational materials adapted to the different learners behaviours. An instructional designer can also exploit the observation traces and indicators in order to modify the learning scenario for upcoming deployments (reengineering). Many researches propose solutions requiring the intervention of an IT expert to assist teachers in defining their observation needs, or in the interpretation of the observation results (for example in order to improve the initial learning scenario (Pernin and Lejeune, 2006)). It could also be interesting to provide learners, during the learning session, with some specific visual tools for representing some relevant information about their progress or knowledge acquisition.

2.2 Current Research Context

Our research activity is part of an editorial chain supporting the observation within a TEL system proposed by (Iksal, 2011). In this context, the instructional designer is considered as the most appropriate actor to define and specify what is required to observe during the learning situation. This leads us to consider the design of the observation activity as a specific phase into the global instructional design process. To this aim, the instructional designer has first to make explicit his observation needs. Then, the learning scenario can be analyzed, driven by the observation needs, which are the description of what to observe, when observing it, how tracking and calculating it, how representing the result, for who and for what.

In previous team research works about the reengineering of TEL systems, we proposed a formal language for describing pedagogical indicators: the UTL Language (*Using Tracking Language*) (Choquet and Iksal, 2007). It allows the definition of observation needs, and the specification of indicators from raw data independently from the language used for the definition of the related learning scenario and independently from the tracks formats. Additionally, we proposed another language (Pham Thi Ngoc, 2011), DCL4UTL (*Data Combination Language for UTL*). It is an extension of UTL that adds the ability to formally specify the automated calculation methods to get the indicators from the collected tracks and observation needs previously expressed using UTL. Thanks to the formalization of indicators, they can then be reused for other observations; the DCL4UTL mappings between indicators and tracks provide designers, for a same TEL system, a reusable and calculable data.

Our specific research work aims at providing the actors of a learning system (especially the instructional designer), with a homogeneous set of tools for 1/ defining observation strategies, 2/ calculating and displaying observation results with an ergonomic and intuitive perception interface. These tools should be used *before, during* and/or *after* the learning session.

3 PRACTICAL AND THEORETICAL STUDIES ABOUT OBSERVATION PRACTICES AND TOOLS

3.1 Practical Study

3.1.1 Presentation of the Survey

In the context of our research, instructional designers are at the center of the observation activity. Our goal is to support them when organizing the observation in a strategic method by adapting it to their objectives and to the characteristics of their pedagogical scenarios. Instructional designers must have the ability to create observation strategies in order to capitalize them for sharing and reusing purposes. They must also have the ability to modify saved strategies for example by adding or removing some indicators. Our goal is also to provide instructional designers with some dedicated tools dealing with the restitution of the observation results, in an understandable and appropriate format to help their analyze. To meet these expectations, the next challenge relies on:

> Identifying instructional designers' needs and practices about the organization of observation activities.

We decided to conduct a confirmatory study

(Wilkinson, 1999) to validate our observations and hypotheses with instructional designers using the UMTice environment. It is an LMS (Learning Management System) based on the Moodle platform. It is used in the University of Maine (France) either for distant online courses or for blended learning in addition to presential courses. The confirmatory nature of our study does not prevent us from exploring other tracks (Le Roux and al., 2004) on the practices of instructional designers in terms of observation.

3.1.2 Assumptions

We stated different assumptions about the instructional designers' needs and practices for organizing the observation of their learning situations. These hypotheses stipulate that instructional designer's objectives could vary from one session to another. When designing the learning situation, he defines some indicators. During the deployment phase of the learning situation, he does not systematically use all the indicators previously defined. Set-up indicators may vary depending on the activities performed or according to some pedagogical aspects of the scenario that the instructional designer wants to evaluate or validate. These indicators can also depend on what he wants to confirm or not with a particular group of learners.

We have also assumed that instructional designers need to organize the observation according to the restitution of the calculated indicators (format): they have to be understood without being an expert in computer languages.

The survey presented in the following sections aims at verifying these hypotheses and highlighting the elements of an observation strategy.

3.1.3 Methodology

To verify and collect the instructional designers' needs concerning the observation of learning situations they develop with the platform, we initiate a process consisting of three steps. The first step of this investigation consists in the realization of individual interviews with instructional designers from the multimedia department of the Technology Institute of Laval, France. This step is motivated by the fact that we have instructional designers available to answer our questions and to give us their feedback on the observation during their use of the UMTice platform. This allows us to check, in a very first time, some elements of our hypothesis. The second step concerns the distribution of a questionnaire for all the instructional designers using UMTice. This questionnaire only proposes closed questions (Droesbeke et al., 1997), mainly because we aim to obtain some quantitative statistics to validate and confirm the conclusions derived from our previous interviews with a reduced community of instructional designers. The choice of the questionnaire is related to the availability of means to conduct such an investigation, the access to a target audience and the ability to have enough answers. Once the information about needs and practices in observation are collected from the first community of practitioners, we realize a simulation with the visualization prototype in which we simulate a concrete example of a learning situation with a strategic organization of observation and indicators visualization. We present this simulation to the instructional designers in order to check if our approach could satisfy their needs. This allows us to validate some aspects of the prototype and to collect some comments and criticisms to improve the functional and ergonomic aspects of the Human Machine Interface.

Figure 1 summarizes the different steps of the investigation with their related objectives:

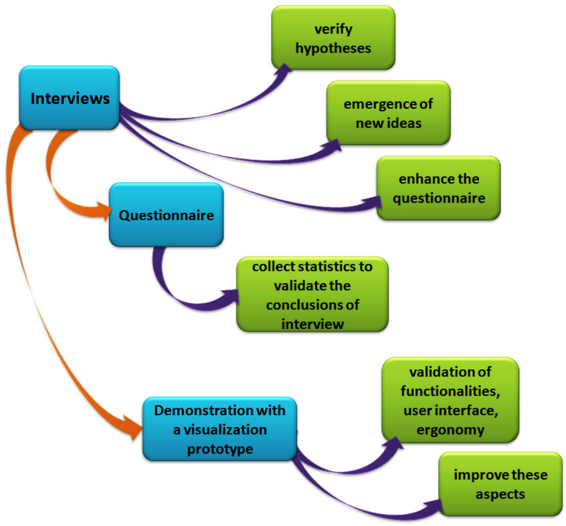

Figure 1: The investigation process.

3.1.4 The Interview Phase

Interview Process

The interviews we made took place individually. Each meeting spent about one hour. The interviews were introduced by the presentation of the research work within which the study takes place. Questions relating to the observation of learning situations were discussed. Instructional designers spoke about their observation activities. They presented the observation tools that the platform proposes to them for monitoring the learning situations. Discussions focused on the needs of organizing observation (autonomy, choice of indicators, etc.), the way of restitution of the results (moment, format, etc.) the needs for broadcasting these results and the possibility of reusing the same organization from a pedagogical scenario execution (session) to another.

The interview has followed a roadmap to treat all the points related to our hypothesis placing the instructional designer at the center of the observation activity. The interviews were, also, an opportunity to test a first version of our questionnaire on the study of needs and practices in observation.

First Analysis of Interviews

The analysis of the interviews made with instructional designers of Multimedia Department of the Technology Institute of Laval allowed us to highlight three different categories of results:

a) Position Relatively to the Existing Devices

Regarding the existing tools, teachers we interviewed indicated that the platform UMTice of the University of Maine already provides tools to observe learning situations: the Moodle activity reports, histories, reports of participation or statistics on the purposes. These tools allow them mainly to identify the resources consulted, the users of a forum and the consultation rate per student of educational resources available online. Teachers said they used this information to get an idea of learners who show a real interest for resources to prepare activities that require the information contained in these resources. Due to poverty of visualization and indicators perception tools, some teachers tried to use an external tool to the platform UMTice, called Gismo (Mazza and Milani, 2004). Instructional designers find easier the analysis, understanding and use of graphics and color codes of Gismo. The teachers using Gismo do not say to be completely satisfied with this tool because they find the number of indicators viewed very small and these indicators focus on the visualization of relational behavior between learners (initiated discussions, participants, exchanged messages, etc.) and not on activities or productions made in solving exercises, for example. Some instructional designers proceed in a different way to consider indicators provided by UMTice. They export them to an Excel file and then analyze them. It appears that this additional activity is time consuming and therefore, after a while of using this method, they stopped to use it.

b) Desired Improvements

The improvements wanted by instructional designers interviewed are many and it is important to mention some of them. There is an unanimous wish to have more structured forms of indicators restitution, such as tables, graphs, and especially time lines and color codes. Teachers interviewed are convinced that the visualization of an indicator in different ways, through different visualization structures increase their understanding of the information carried by the indicator. Teachers expressed the need to identify the most active members through forums and who participate the most in collaborative learning. Some teachers have expressed their wish to go to a finer grain in the visualization of consultations of the resource base. They want, for example, to know the indexes of pages consulted, consultation time, current activity during the consultation, etc. Teachers have also expressed their desire to have an evolution in the time of the indicator values to verify that the interventions made on pedagogical scenarios have improved the learning activity.

c) Appreciation of the Proposed Solution

The analysis of the outcome of the interview also shows that instructional designers are favorable to the idea of having a tool that provides a rich choice of indicators to be displayed, depending on the activity carried out, and return them at the desired time and in a more accessible and understandable format without using an additional activity. It is important also to note that the teachers interviewed found interesting the possibility to use in their observation activity, an editor to define configurations of observation, to capitalize, share and reuse them. It should be noted, too, that the need for indicators in real time is not really expressed, insofar as they are not faced with such a situation in their use of the platform, but they find the idea interesting. Instructional designers showed a real interest in our proposal to provide them with a graphical editor of observation strategies whose use could be available to all teachers, whatever their level in computer science.

3.2 Outcomes from Theoretical Studies

Many research works dealt with some observation aspects. Some of them are focusing on the display of the observation results to the right recipients. They generally provide a set of visualization tools allowing a better understanding and interpretation of the results. The visualization of indicators can be achieved by means of different views, supporting the isolation of interesting phenomena, and allowing an intuitive vision of what happened (Dyke and al., 2009).

An overview of these works is presented in (Ouali and al., 2013). These works have developed specific tools for displaying the results of indicators. Some of these tools allow the monitoring of learning situations in real-time (France and al., 2006) (May, 2010). Other ones limit the visualization to the end of the learning session (Mazza and Dimitrova, 2004) (Heraud and al., 2005). Some tools combine several viewing format for a same indicator (Greenhalgh and al., 2007) (Morrison and al., 2006). Other works propose the indicators visualization thanks to a horizontal time axis (Van Diggelen and al., 2008), by the means of contingency graphs (Heraud and al., 2005), or by Chernoff Faces (France and al., 2006). The tools from (Greenhalgh and al., 2007) demonstrate the added value of a computer-assisted traces analysis but they focus on very specific data and require further developments to adapt their techniques to TEL systems. Some tools specifically address tutors in order to provide them with monitoring elements for supervising some learning sessions (Heraud and al., 2005). Most of calculated and visualized indicators are exploiting traces from communication activities between participants in a session (May, 2010) (Mazza and Milani, 2004). Some works are very TEL-system-dependent and only focus on specific generated traces. It does not allow the exploitation of their tools and techniques on other platforms (Mazza and Milani, 2004) (Mazza and Dimitrova, 2004). We also notice that the majority of existent tools focused the visualization of indicators on a very limited set of them, generally calculated from traces of message exchanges. It is also important to consider the lack of research works taking into account the context of the pedagogical scenario.

If we consider research activities in the field of observation particularly concerning learning situations and perception of educational indicators, we are able to present some facts related to the teacher or the instructional designer. The first concerns the lack of results directly designed and provided for the teacher: a majority of projects focused on learner support activities (Van Diggelen and al., 2008) and activities of researchers (Dyke and al., 2009). The specific needs of the teacher or the instructional designer, which may vary from one session to another, are not taken into account. We noticed, moreover, that the viewing covers on the same indicators whatever the scenario of the learning session. These indicators are often proposed directly by the learning platform; they are not defined at a sufficient abstract level that could improve the understanding and the observation setting up for instructional designers. So, it is not possible to decide neither indicators to display, nor the time of viewing, etc. We also notice that teachers often feel constrained by the complexity of the technical environment, so it is difficult for them to think about and design the observational process of the learning situation without technical considerations. In terms of indicators restitution, the visualization means available often require learning and training efforts to use them.

The state-of-art we performed has highlighted a real need for a strategic organization of the observation activity. Several questions remain:

> How to help the teacher or instructional designer to organize his activity of observation strategically? How to take into account the observation objectives of the teacher or the instructional designer? In what kind of form the results of the observation should be returned?

4 THE PROPOSAL

4.1 The Overview of an Observation Strategy

The concept of observation strategy is related to how the observation is organized. Indeed, this organization is concretely driven by various observation needs for different actors and different objectives. It is also intimately linked to how the learning situation is organized, the learning scenario,

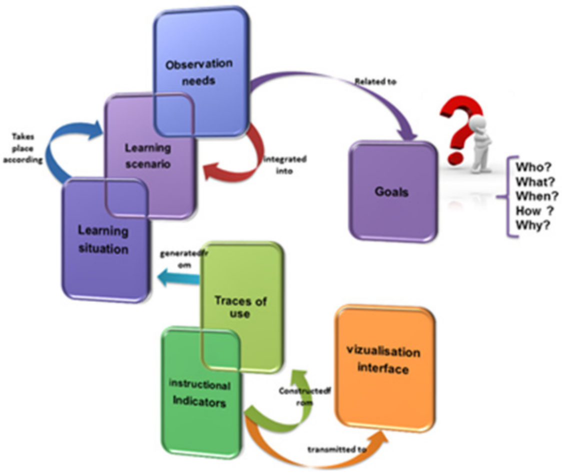

Figure 2: A general idea of our concept of observation strategy.

and its actors and pedagogical objectives. But for a same learning situation, various strategies can be defined according to the actors targeted; their observation needs, the considered tracks, the elicited indicators, the distribution and representations of the results, and so on. Figure 2 draws this general concept of observation strategy.

Such strategies should try to answer to these questions: does the right actor observe the right information? At the right time? With the right format? Does it correspond to his observation needs? Does the information presented (indicator) is at such an abstract level from the TEL environment tracks to be useful?

4.2 Definition of the Observation Strategy

The observation strategy consists of a set of indicators, their perception mechanisms (form of restitution of these indicators) and the recipients of these indicators. It is composed also of its context of use (in connection with the pedagogical scenarios), the objectives of the observation (learner assessment, adaptation of the pedagogical scenario, monitoring the learning session etc.) and time of observation (during the session, after the session, the completion of an action, etc.).

Although the strategy can evolve progressively with uses, it must nevertheless be considered ahead of the learning situation. It must be extensible by adding new indicators. It must be capitalizable to be reused. Observation Strategy must also be adaptive to the context of learning scenario.

4.3 Formalization of the Strategy

Figure 3 shows the meta-model of an observation strategy. In this meta-model, we find out the composition of an observation strategy including a specific context and multiple components. Defining the context requires the definition of four elements: the elements of the scenario, the groups of individuals to observe, the indicators to watch and the perception means available. The elements of the scenarios can be resources or activities. The groups are composed of individuals each having a specific role during the course of the learning situation. A monitoring component strategy consists of a set of triplets "indicator, individual perceiving means" and the time of observation. The triplet is set to be displayed by a particular recipient. For each indicator, at least one means of perception is associated with the possibility or not to change for each indicator the means by which it can be viewed. The observation time can be defined in two ways: by listing the elements of the educational scenario that must be observed or by defining a period indicating the activity by which the observation begins and the activity by which it ends.

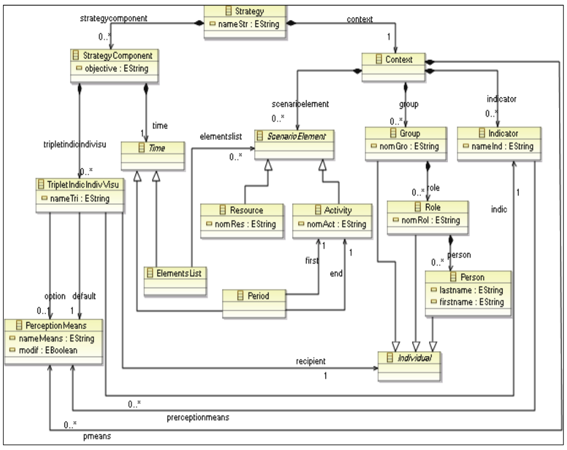

Figure 3: Meta-model of an observation strategy.

5 EXAMPLE OF DEFINING AN OBSERVATION STRATEGY

5.1 Description of the Learning Scenario

In this example, we want to illustrate the specification of an observation strategy by a teacher or instructional designer. The learning situation to consider in this example comes from an experiment performed in (Pham Thi Ngoc, 2011). This experiment was performed in the Multimedia department in the Laval Institute of Technology, France. It involved 90 students in the first year of DUT degree, over a practical session. These students were divided into six groups. The educational objective of the session is about object-oriented programming in Java in the course "Basics of object-oriented programming". For a period of three hours, the student must answer twelve questions through a programming environment called Hop3x (Lekira, 2011). Teachers have defined specific indicators for each of the 12 questions

5.2 Definition of the Observation Scenario

We want to observe the solving of the 12 questions by the students participating to the practical session.

The indicators to consider are the transverse ones for the 12 questions. To respond to observation objectives related to the designer, tutors and learners, the designer has defined the following elements:

- For each indicator, viewing default means are defined, and other means are available to the designer so that he can choose another way or other means for the same indicator.
- The designer defines the time of observation as the time spread over all activities of the scenario.
- Recipients of the observation are the designer, both tutors and 90 learners.
- The designer watches all the transverse indicators. Tutors observed the indicators 1 to 5. Learners observe the indicators 8 and 9.

With information relating to the experiment's progress, we can define the strategy described in Figure 4. In this figure, we find the defined triplets and the period for viewing. For the triplets, the individual considered is the designer, and for each of the indicators to visualize, a perception means is set by default. For some indicators, an optional means is associated. The moment of the indicators displaying is the end of processing each question, that is to say the time of transition to the next question because in Hop3x the calculation of the indicators s done in the move to next question.

Period	At the end of processing each of the 12 questions		
Target	Indicator	Displaying Tools	
		default	Optional
Designer	The frequency of manual compilation (per minute)	*rod graph*	*bar graph*
	The execution frequency (per minute)	*rod graph*	*bar graph*
	The rate of correction of errors in compiling	*bar graph*	*grouped column chart*
	The percentage of meaningful variable names	*grouped column chart*	*bar graph*
	The percentage of meaningful method names	*grouped column chart*	*bar graph*
	What is the average time spent per question for each student?	histogram	
	The number of compilations per question and per student	histogram	

Figure 4: Example of a specified observation strategy.

5.3 Formalization using the Meta-Model

Because we plan to use a homogeneous set of *Domain-Specific Modeling* tools (*Eclipse Modeling Framework and Graphical Modeling Framework* (EMF & GMF)) in order to drive the development of the observation strategy editor, we on purpose propose to formalize the previous example by using the Eclipse Metamodeling Framework. To this end, we formalize the observation strategy meta-model as an *ecore* meta-model and we use the tree-based editor generated by EMF to build a formalized instance of our example. Such approach certifies that this instance is conformed to our meta-model-conformance. It is also a relevant method to test the meta-model semantics. According to the meta-model, we have first to define all the elements composing the *context* and then, secondly, we can define the different triplets *indicator /individual / perception means* and *moments of observation*.

6 CONCLUSIONS

We presented in this paper, the problem of observation of learning situations and perception of pedagogical indicators. We discussed in the first instance, the notion of observation in a TEL environment. We are interested in a second time to the research context in which this work takes place. We have presented and discussed thereafter, an investigative process to understand the needs of instructional designers, related to the organization of the observation of learning situations. This investigation provides three different phases. The first one consisted in interviews with instructional designers. During these interviews, designers expressed their points of view on the observation devices provided by the platform they use. They were also able to express their expectations to improve the existing system and their appreciation for the functionalities we have presented them to organize their observation activities strategically. The next phases of the investigation will focus on the distribution of a questionnaire to a higher number of instructional designers to validate the results obtained in the interviews, and on the development of a demonstration with a visualization prototype in order to verify if it meets their expectations and improve it, taking into account their assessments. Thanks to that study, we identified the need for a strategic organization of observation. In response to this, we have proposed the concept of observation strategy which aims at performing the activity of observation effectively. This concept was described using a meta-model, and it was illustrated with an example of defining an observation strategy, applied to an experiment. Currently we are working on developing a prototype of a graphical editor of observation strategies. The idea of this prototype comes from the desire to provide an interface allowing the definition of strategies by describing the context and the strategy components. We are also working on the development of a dashboard to display the indicators in accordance with the defined strategies.

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Piloting the eBig3
A Triple-screen e-Learning Approach

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Keywords: e-Learning, t-Learning, m-Learning, eBig3 Learning.

Abstract: In this report / study we present our recent progress on multi-screen e-learning development entitled eBig3. It is a new approach to technology supported education encouraging involvement in lifelong learning education. The approach effectively integrates the popular technologies of television, Internet, and mobile phones Here we present the results of ten course pilots offered in 2013 with the eBig3 media formats. The target group for the courses was the general public. And the three-pronged approach worked; the response showed a radical increase of registration for eBig3 courses compared to traditional registration for online courses. The course delivery formats were also more successful than blended learning formats. Our results showed that the new approach significantly increased the availability of eCourses and that users felt encouraged to stay the duration of the course. Moreover, the results indicated that the approach helped to close the gap between expectations and actual achievements for life-long-learning in general.

1 INTRODUCTION

Each big breakthrough in education technology has announced and encouraged the creation of a new type of learning (Pfeffer, 2012). TV-education was inspired by the large scale penetration of television into people's homes; m-learning developed together with smart phones (Ducey and Phalen, 2011), (ITU-D, 2010), (ITU-D, 2009), (ITU, 2008), (Google, 2012), (Zaller, 2013), (Turrill, 2013), (Byers, 2013). E-learning initially was regarded as a Personal Computer technology for education. Nowadays we usually refer to all digital education technologies as learning. The new twist and challenge is when learners are using all three technologies to suit their style and convenience. Developers, however, design separate approaches for each of the big three learning technologies: e-learning, m-learning and t-learning. To meet the challenge of applying all three technologies at the same time and adjusting them to the habits of users, we designed an approach that was user sensitive and functioned with the three approaches simultaneously. The eBig3 pilot incorporates these adjustments and forges a new path for technological learning (Kapenieks et al., 2012b) .

With the eBig3 approach, we assign complimentary applications for TV, Internet, and mobile phone to ensure high quality user-friendly learning. eBig3 has the capacity to respond to the skills/habits of a large target group of users that spans all age groups of life-long learners. eBig3 learning tends to reach, deliver content, and learning support to a diverse group of users; nor does it require continuous upgrade of technology and special skills (Kapenieks et al., 2012c).

The project has been carried out in a cross-border region of Latvia and Lithuania and included universities from both nations. The target group for the eBig3 courses was the general public. This paper reports on the Latvian results. At the beginning of the project researchers have used "Enterprise Knowledge Development (EKD) method to capture and systematize the experts' and stakeholders' knowledge about various learning approaches and content delivery technologies. Each of three selected technologies (computer, internet, mobile, and television were tested for material qualities and interaction capacity to determine which was the most suitable for each function. Then the Technologies were combined to be responsive to the widest possible audiences. We achieved audience interest and engagement by: a) exhibiting entertaining videos clips on TV, each lasting about 12 minutes; one of more such video clip had been prepared for each course; b) ensuring a smooth registration process and providing regular organisational and context dependant learning support over the SMS messaging service; c) making full instructional material available in an online learning environment. After initial review of the outcomes and formulating the first eBig3 model we designed the prototype for the eBig3 course (Kapenieks et al., 2012a).

2 eBig3 COURSE PROTOTYPE

The eBig3 three course prototype consists of three learning contents formulated to fit each media type: t-content, e-content, and m-content. We modelled the t-content on the Discovery documentaries. We designed an engaging video on course topics and exhibited it on TV. This video is as interesting to watch as a traditional TV movie. At the bottom of the film appears a banner inviting the public to join the course with complete registration details provided (Figure 1).

Figure 1: eBig3 course T-component with banner at the bottom of the screen inviting the public to join the course by sending a SMS to: “eBig3, first name, last name and course number”.

The procedure to sign-up for the course is simple. A viewer only needs to give his first and last name and course number she is interested in and send this information with an SMS. Signing up for additional courses follows the same procedure.

It is a simpler procedure than completing a user profile in an Internet environment. The response is almost immediate; in about the minute a user receives a login. Our system corrects some typical mistakes, and most registration attempts are successful. In case of an unsuccessful registration, the user receives an error massage and repeats the registration process. Nearly all users successfully register after the second or at the most the third attempt.

Typical problems encountered are users losing logins. The recovery process is simple. The eBig3 system sends an SMS with the password that looks like this: “ebig3 password”.

An important application of the m-component is sending learning support. E-learning courses traditionally experience a high drop-out rate; we therefore used the mobile SMS system to send additional messages in certain selected situations to encourage user efforts. We have identified these events as follows:

- Sending a congratulatory message after joining the course;
- Sending friendly reminders to be more active in the course;
- Confirming active participation in a Course Unit;
- Informing about face-to-face seminar sessions and providing the time and place;
- Sending a congratulatory message after course completion;
- Sending information about newly published courses;
- Other important communications about learning events.

The SMS system helps to maintain virtual contact with learners. It strengthens the living contacts that are maintained by seminars and phone contacts.

The SMS messaging system is triggered by the following events:

- Planned event data base;
- Unique actions of users (like registration);
- Users’ behaviour analysis and results.

E-content is central to the course material delivery process; it ensures that the content is consistent with the level of the learning objectives and that the volume, assessments, tests etc. are well matched to user learning levels. The e-content is located in the Moodle learning environment. The users’ behaviour is registered by mouse click data in each course unit.

3 eBig3 COURSE DELIVERY

eBig3 course delivery was organised after registration. Ninety percent of the registered users entered the course using a login received via a SMS (Figure 2).

The eBig3 courses and seminars were organised at four universities in Latvia: Riga Technical University, Daugavpils University, Liepaja University, and Latvia University of Agriculture.

After the first week of activities a motivational SMS was sent to all participants. The SMS content was selected on the bases of user activities in the course.

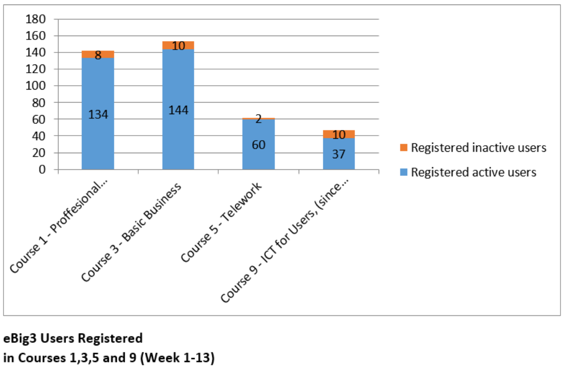

Figure 2: Registered users and users entering the course.

The seminars were organised every week on regular rotating basis at one of the participating universities. The information for the next seminar was sent by SMS to each registered user. These activities maintained the momentum of the on-going learning.

The users completed the tests, exercises and final assessment work; they also communicated with the course teachers.

The users who successfully completed the course with final assignment work received the partner university certificate.

4 ebig3 COURSE PILOTING

The information on eBig3 courses-- titles, learning objectives, delivery approach-- was published in the www.ebig3.eu portal.

1. Professional Communications (23 Learning Objects (LO))
2. Basic Business (190 LO)
3. Information Society and Telework (82 LO)
4. Computers for Beginners (58 LO)
5. Computers for Users (170 LO)
6. Landscape Architecture and Design (54 LO)
7. Renewable Energy Resources (39 LO)
8. Latvian-Lithuanian Communications (27 LO)
9. 23 things to know for Business Beginners (59 LO)
10. Internet Marketing and Advertising (1 link to course in an external environment)

The most popular courses were:

1. Professional Communications
2. Basic Business
3. Information Society and Telework
4. Computers for Users
5. Landscape Architecture and Design

The course content was uploaded in Moodle except for the Course No 10 that was located in another e-learning environment linked to Moodle.

There were was a 12 minutes long video broadcasted 30 times on Latvian Regional TV. Each course had separate video clip with a banner at the lower end of the screen inviting viewers to join eBig3 courses by sending an SMS. The Project flyers were also distributed in libraries and municipalities in the vicinity of surrounding the partner universities.

The number of participants rapidly increased. Figure 3 shows the number of participants in first eleven days of course delivery

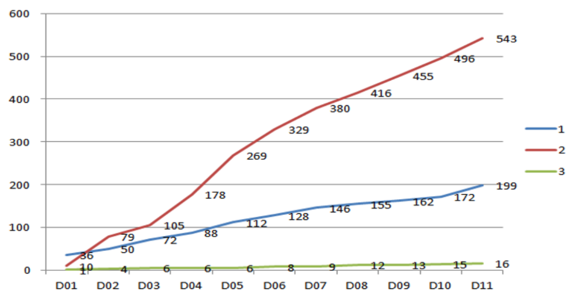

Figure 3.

Figure 3 shows the number of participants in the Latvian speaking area of the first eleven days of course delivery. No. 1 graph eBig3 course registration that is accomplished by sending an SMS giving first and last name as well as course number; No. 2- are public IT courses available in the Riga City portal www.riga.lv. The public was informed about them through large scale advertising, No registration was necessary. No. 3- public business courses advertised on a medium scale; users were required to give profile information online.

Figure 4 shows the increase of eBig3 users during the first 13 weeks of course delivery.

Each course had number of learning objects, from 23 to 190 eBig3 information system collected data by mouse clicks for each course.

We calculated the cumulative ratio of the number

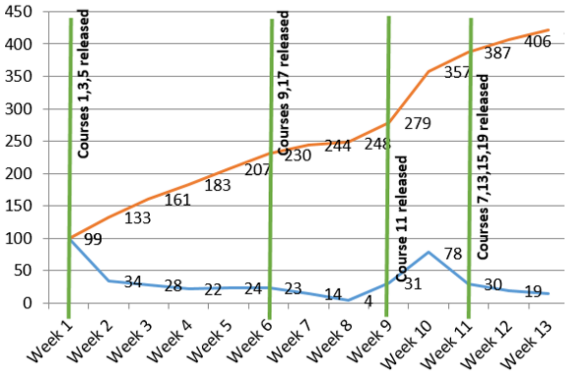

Figure 4: The number of participants in Latvian speaking area in the first 13 weeks of eBig3 course delivery (1); and number of new registrations every week (2).

of average user mouse clicks for each course:

1. Professional Communications – 1,50
2. Basic Business – 0,48
3. Information Society and Telework – 0,83
4. Computers for Users – 0,59
5. Landscape Architecture and Design -1,39

The cumulative ratio is the average ratio of mouse clicks per the number of learning objects for all users who entered to course. The next Figure 5 shows the increase of the cumulative ratio vs. the number of learning objects.

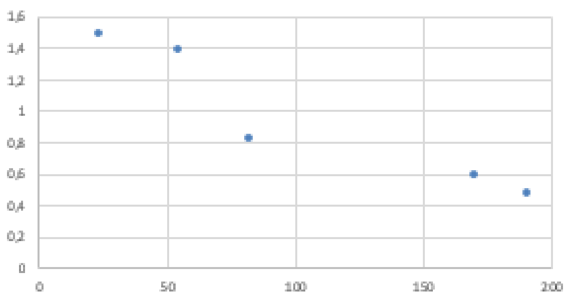

Figure 5: Cumulative ratio (mouse clicks / number of learning objects) vs. the number of learning objects for five of the most popular eBig3 courses.

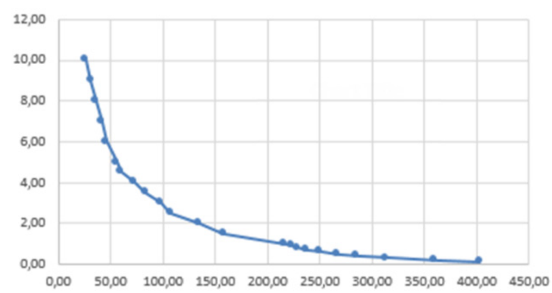

Figure 6: Number of effective volume of eBig3 courses vs. the number of users.

We calculated how many learning objects were clicked by each participant. The next Figure 6 shows that more than 216 participants from 523 used content with volume for more than one eBig3 course. More than 267 participants used content with size for more than 0,5 eBig3 course; and more than 403 participants used content with size for more than 0,1 eBig3 courses.

5 CONCLUSIONS

The conclusions are listed below:

1. The registration for e-courses with SMS with the eBig3 approach shows a strong increase of participants compared with the traditional internet registration procedure.
2. Half of the eBig3 learners who joined the course covered at least 50% of one course content in terms of volume.
3. The triple screen eBig3 approach better met the needs of life-long-learners than traditional single screen based eLearning.

ACKNOWLEDGEMENTS

This research has been supported by a grant from the European Regional Development Fund (ERFD/ERAF) project "New User behavioural interpretation algorithms to facilitate an efficient transfer of knowledge within an e-ecosystem (JAUZI)", Grant Agreement 2013/0071/2DP/ 2.1.1.1.0/13/APIA/VIAA/023.

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Designing Physics Game to Support Inquiry Learning and to Promote Retrieval Practice

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Keywords: Physics Games, Game Design, Simulation, Pseudo-tutor, Easy Authoring.

Abstract: Instruction in physics aims at achieving two goals: the acquisition of body of knowledge and problem solving skills in physics. This requires students to connect physical phenomena, physics principles, and physics symbols. Computer simulation provides students with graphical model that unites phenomenon and principles in physics. However, such minimally guided approach may harm learning since it overburdens the working memory. Also, simulation is inadequate in promoting problem solving skills since students need to exercise with a variety of physics problems. Intelligent tutoring systems (ITS), in contrast, train students in solving physics problems. In this paper, we designed an online puzzle game in physics that combines simulation and pseudo-tutor (namely QTut). We addressed three challenges: extensibility, scalability, and reusability in designing our game. We conducted usability tests with 10 participants on the game prototype to study the user performances and perceptions for improvement. The results indicate the game as educative and moderately entertaining. The use of scaffolding in the game positively contributed to the game learning experience. Moreover, the game GUI expressed information well that made the game understandable, even with little instructions.

1 INTRODUCTION

Instruction in physics aims at achieving two goals: the acquisition of body of knowledge and the ability to solve quantitative problems in physics. To achieve the learning goals, physics instructions should examine the knowledge structure of physics. Physics organize the body of knowledge into three levels: the macroscopic level corresponds to physical objects, their properties and behaviour; the microscopic level explains the macroscopic level using concepts, theories and principles of physics; and the symbolic level represents the concepts of physics as mathematical formulae (Johnstone, 1991). Consequently, physics instructions need to advocate the connection of those levels to the students.

Lack of knowledge and/or misconceptions at the microscopic level leads students to difficulties in solving physics problems (Heyworth, 1999). The use of concrete models, analogies and graphics may help students to overcome those difficulties. In inquiry learning, computer simulation graphically models physical objects and unites the macroscopic, the microscopic, and the symbolic levels together. This approach urges students to actively seek questions, explore the simulation environment, and discover knowledge based on their observations.

However, such minimally guided approach may harm learning since it does not align with working memory limitations (Kirschner and Clark, 2006). This, to an extent, necessitates the use of scaffolding, which is essential particularly for inquiry learning (Jong, 2006). The use of scaffolding reduces cognitive load of the students when using computer simulation. A meta analysis also supported the use of explicit instructions in learning (Alfieri et al., 2011). Moreover, guided inquiry learning also helps students to plan their simulation experiments (Bonestroo and de Jong, 2012).

Nevertheless, using simulation alone is inadequate in promoting problem solving skills. It is also important for students to exercise with a variety of physics problems and to perform retrieval practices at microscopic and symbolic levels (Karpicke and Blunt, 2011). Intelligent tutoring systems (ITS) train students in problem solving skills using apprenticeship and problem solving models (Woolf, 2009).

Given the advantages of simulation and tutoring system, we combined simulation and tutoring system into a serious game for learning physics. Serious games have potentials in instruction particularly for engaging the audience in challenging and contextualized activities; and students are encouraged to query information, apply knowledge and practice skills (Wouters et al., 2013; Connolly et al., 2012). We designed the game as an online physics game accompanied by a pseudo tutor to support learning. The game graphically simulates the macroscopic level whereas the example-tracing tutor (pseudo tutor) explains the physical phenomenon at both microscopic and symbolic levels. We conducted usability tests on the game prototype to collect user performance and perception of the game as a learning media.

The remainder of the paper is organized as follows. Section 2 relates our work with the current state of the arts, whereas Section 3 explains our game in details. Section 4 discusses about the usability tests, and Section 5 concludes our paper.

2 RELATED WORKS

Constructivist teaching has the greatest potential to enhance learning where learners actively construct knowledge through inquiry, apprenticeship, and collaboration (Woolf, 2009). In physics, constructivist teaching uses computer simulation to challenge learners constructing their own questions, exploring the simulation environment, and inferring knowledge similar to scientists.

Numerous computer simulations for learning physics are available in the market. For instance, PhET project provides a variety of interactive physics simulations (Perkins et al., 2006). The PhET project investigated several design factors of engaging and effective simulation (Adams et al., 2008a; Adams et al., 2008b). The finding suggests that providing driving questions encourage students to explore the simulation (Adams et al., 2008c). Furthermore, balanced challenges in form of affordance, constraints, analogies, and the use of multiple representations maintain students engagement (Podolefsky et al., 2010).

Several studies showed that the use of scaffolding improves the effectiveness of simulation. For instance, traditional instructions enhanced learners understanding of the simulation (Kolloffel and de Jong, 2013) and helped them to plan their experiments (Bonestroo and de Jong, 2012). The use of concept mapping with simulation enhanced deep learning (Gijlers and de Jong, 2013).

However, computer simulation overlooked problem solving in physics that most students find it difficult. In contrast, Intelligent Tutoring Systems (ITS) and Fading Worked Example (FWE) can be used to nurture problem solving skills. For instance, Andes tutor trained students on solving physics problems (Vanlehn et al., 2005) improved the average exam score of the students. Likewise, FWE supports effective learning but combining ITS and FWE did not contribute to better learning (McLaren et al., 2008).

Combining a physics simulation with a tutoring system may provide students with a graphical tool for exploration (the macroscopic level) and a training tool for problem solving (the microscopic and the symbolic levels). A practicable approach is using serious games to combine both simulation and tutoring systems. Serious games have strengths to appeal and to motivate students (Connolly et al., 2012). Meta analysis showed that games can be more effective than traditional instructions, but only when considering working memory limitations (Wouters et al., 2013).

In this paper, we created an online puzzle game in physics that uses simulation to represent physical objects at the macroscopic level and a pseudo tutor (namely QTut) to explain physical phenomenon at the microscopic and the symbolic levels. QTut provides students with hints and feedback; and it responds to student queries. As a prototype, we created a physics game for bachelor degree students. We conducted usability tests to study the user performances and perceptions of the game for improvement.

3 GAME SYSTEM DESIGN AND DEVELOPMENT

3.1 Design Considerations

The game system was developed using bottom up approach by identifying challenges, devising solutions, designing each solution as a module, and integrating the modules into complete system. The graphical user interface (GUI) and the gameplay emphasize the use of scaffoldings in form of driving questions, informative feedbacks, user queries, and QTut responses.

The game was implemented using HTML5 and JavaScript for rich web experiences and JSON (JavaScript Object Notation) for lightweight data storage. We followed rapid prototyping to iteratively create prototypes over short period.

3.2 Identifying and Addressing Challenges

We considered three challenges in developing the game system: extensibility refers to the ease to produce a variety of games for different topics, scalability means the ease to attach new modules to the system, and reusability corresponds to the use of some modules for other purposes.

3.2.1 Extensibility

A. Game Level and Game Format

We created game level and game format to allow extensibility (Pranantha et al., 2012). The game level clusters learning topics into levels based on their complexity. The game format sets each game level as series of tasks a puzzle set drawn from the database (a JSON file). A task or a task item is either a closed ended question about a simulated event or an action request in the simulation area.

Figure 1 described a puzzle set that consists of several task items. Each task item has two types of data: the scaffolding data and the simulation data. The scaffolding data (Program 1) has an id, a question, a list of feedbacks, a sequence of possible answers, and an index of correct answer. Subsequently, the simulation data (Program 2) includes a collection of objects and a list of available responses to the action request.

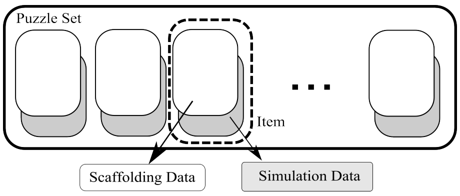

Figure 1: A puzzle set and a task item.

```
Program 1 (Scaffolding data):
{
     id  : 1,
     question : "What is the friction force?",
     feedback : ["Friction force = Normal force
                  x cos(alpha), where alpha is the
                  angle of the friction force with
                  respect to horizontal ground",
                 "Well done"],
     answerLst  : ["120 kg.m/s2","115 N","117 N",
                   "114 kg.m/s2"],
     idxCorrectAns: 2
}

Program 2 (Simulation data):
{
     id  : 1,
     objects : [ {
                  "id": 1,
                  "name": "crate",
                  "class": "crateActor",
                  "position": {"x": 0, "y": 230},
                  "size": {"w": 640, "h": 20},
                  "image":"images/force/crate.png"
                 },
                 ...
               ],
     responseLst: {
                  "response": ["createJoint"],
                  "objects":[{
                                 "to":["extension"],
                                 "anchor":{"x":1,"y":1}
                             }]
                  }
}
```

Using the game format, a game consists of a sequence of inter-related tasks can be easily created to learn problem solving skills. Some tasks can be recalled several times to promote retrieval practice which is essential for learning (Karpicke and Blunt, 2011).

B. Pseudo Tutor

Beside the scaffolding data in the task item, we created QTut, a pseudo tutor. QTut allows students to query some information in relation to the task at hand.

To support the extensibility of QTut, we created *knowledge triplet* (Qs, R, DA), where Qs refers to a list of query samples; R represents a response to a list of query samples Qs; and DA denotes dialog act (Program 3). The knowledge triplet (subsequently called triplet) represents QTUt knowledge on learning topics. Consequently, the number of triplets is contingent to the coverage of the learning topics in the game.

```
Program 3 (Knowledge tripets):
{  "Qs": ["Define normal force","What is
         normal  force"],
   "R": "Normal force  (N) is the component
         (perpendicular to the surface
         of contact) of the contact force
         exerted on an object by,
         for instance, the surface of a
         floor or wall, preventing the object
         from penetrating the surface",
   "DA": { "key": ["what", "define"],
           "intention": "ASK_EXPLAIN" }     }
```

We use the triplets to construct a N-gram term frequency - inverse document frequency (TF-IDF) table (Table 1) that measures how concentrated the occurrence of a given word in a collection of triplets. Words with high TF-IDF numbers imply a strong relationship with the triplet they appear in, suggesting that if that word were to appear in a query, the triplet could be of interest to the student.

Table 1: An example of N-gram TF-IDF table with 2 triplets.

N-gram words	TF-IDF of triplet 1	TF-IDF of triplet 2
Net force	0.40	0
Normal force	0	0.4
Force	0.10	0.10

TF-IDF is computed as follows. Suppose we have a collection of N triplets. Define f_{ij} to be the frequency (number of occurrences) of term i in triplet j. Then, define TF_{ij} to be f_{ij} normalized by dividing it with the maximum number of occurrences of any term in the same triplet (1) (Rajaraman and Ullman, 2011).

$$TF_{ij} = \frac{f_{ij}}{\max_k(f_{kj})} \tag{1}$$

Whereas the IDF for a term is dened as follows. Suppose term i appears in n_i of the N triplets in the collection. Then,

$$IDF_i = \log_2 \frac{N}{n_i} \tag{2}$$

The TF-IDF score for term i in triplet j is then computed as

$$TF - IDF_{ij} = TF_{ij}.IDFi \tag{3}$$

We developed a Naive Bayes classifier to determine the similarity between a query and the triplets using TF-IDF information (Manning et al., 2008). QTut subsequently ranks the similarity values in descending order and removes triplets that have similarity values below a certain threshold. QTut performs intention matching on the DA of the remaining triplets with the following rules: if it finds a match, then returns the corresponding triplet; otherwise, returns the triplet with the highest similarity value.

3.2.2 Scalability and Reusability

To facilitate scalability and reusability, the game system is divided into functionality modules (Figure 2): *a*) tutoring module delivers questions, provides hints and feedbacks, and responds to queries; *b*) physics simulation module handles all graphical events based on laws in physics; *c*) delivery module draws a task item from the puzzle set either in random, sequential, or difficulty based order; and *d*) data module accesses, organizes, and manipulates game database (i.e., game contents, game configuration, and user log).

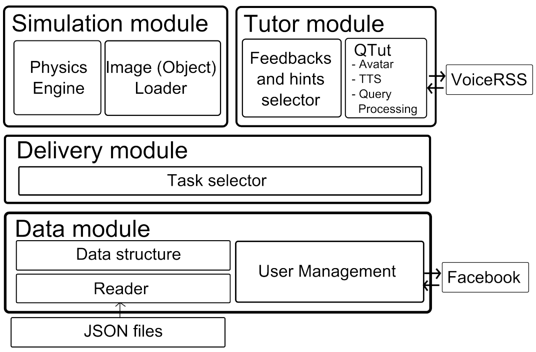

Figure 2: A stack of modules as a complete system architecture.

QTut (in the tutoring module) has two modes: text only and text with speech. We use a free text-to-speech (TTS) web service[1] to convert texts into speeches for the latter mode (Figure 3). QTut sends the texts to the TTS web API using HTTP GET and the TTS web API subsequently synthesizes the speeches and sends them to QTut.

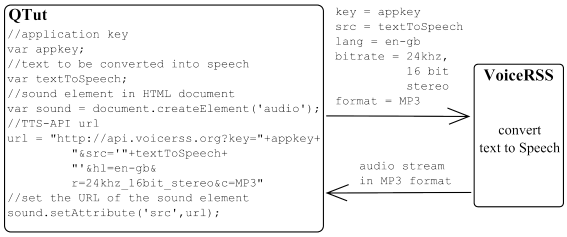

Figure 3: Converting Text to Speech.

To minimize the needs of user management and to support the game distribution, the system is connected to a social networking platform (Facebook) using *Facebook Javascript API*[2]. The system extracts user information on Facebook to be stored into the database.

3.3 Gameplay

Gameplay refers to formalized interaction that occurs when players follow the rules of a game and experience its system through play (Salen and Zimmerman, 2003). Game rules are, therefore, the heart of any game which distinguish game (e.g., a football match) from play (e.g., two kids pass a ball to each other). Furthermore, instruction process -presenting new information, integrating new knowledge, and connecting new knowledge with prior knowledge- is essential in learning (Ferguson-hessler and de Jong, 1991). In serious games, game rules and instruction process are entwined to deliver fun yet educative gameplay. The rules should be easy to comprehend and the instruction process should consider working memory limitations.

The game rules are as follows. All game levels are initially locked except at the base level (level 1). For simplicity, all task items in a level have the same weight for scoring. However, each level has three most difficult task items which each is indicated by a star. If a student answers a starred task item, he will receive one star.

A level has a topic related to its preceding and succeeding levels. For instance, force and torque can be

[1]VoiceRSS Text To Speech (http://voicerss.org/)
[2]Facebook Developer API (https://developers.facebook.com/)

two successive levels. If a level is unrelated to its preceding, the QTut presents an introduction to denote topic transition. A student may progress to a level (i.e., unlock a level) if he has passed its preceding level. A student completes a level if he earns at least two stars and scores above a certain threshold. During the game, a student may query QTut about concepts, formulas, and terminologies. The game rules do not impose timeout but we use the timer for logging purpose.

3.4 Graphical User Interface (GUI)

The layout of the game GUI was designed using grid systems to group all elements according to their functionalities. This allows the game users to easily comprehend the interface (Elam, 2004). Figure 4 (left) shows the wireframe of the game GUI: tutor area on the top right consists of a tutor avatar and an input text to enter query for the tutor, information area on the middle presents feedback and task from the tutor, and simulation area on the bottom plays physics events. The final GUI of the Physics game prototype is shown in Figure 4 (right).

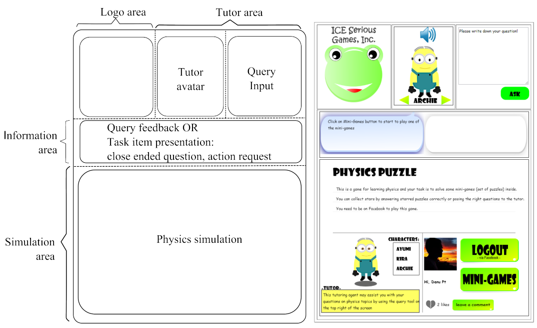

Figure 4: the wireframe of the game GUI (left) and the game GUI (right)

The GUI elements (e.g., buttons and playable objects) use the feedforward and feedback concept to allow intuitive interaction. Feedforward is the information that occurs during or after user action, for instance, on-screen messages indicating what to do. Feedback is 'the return of information about the result of a process or activity' (Wensveen et al., 2004). For instance, clicking on a button opens a new window.

Figure 5 shows the use of feedforward and feedback in a Logout button. Feedforward conveys an implicit message that the logout button is click-able by changing its color upon mouse-over event; and the feedback responds to user action (a click) by changing the logout button into a login button. Feedforward is also used to help students in problem solving. For instance, a calculator button appears if a task item

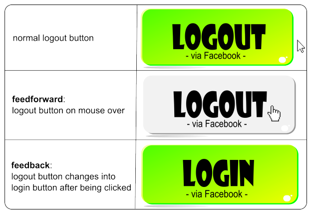

Figure 5: An example of feedforward and feedback in a Logout button.

asks student to calculate force. The physics simulation shows a ruler if student needs to measure length or distance.

3.5 The Physics Game Prototype

The Physics game prototype, intended for bachelor degree students, has two levels: force and torque. The first level consists of nine close ended questions. The questions are either conceptual or quantitative problems. The second level has six action requests that demands student to interact with objects in the simulation area. Figure 6 (top-left) shows a list of game levels where all levels are locked except level 1 (force). Figure 6 (top-right) shows a task item in the first level that asks about stationary state. Figure 6 (bottom) shows a task item in the second level that demands student to balance the mobile toy. Each correct answer is awarded with ten points and a starif the task item is a starred task item. A student passes a level if he earns two stars (three stars are available in each level) and scores above 50% (i.e., 50 points for level 1 and 30 points for level 2).

Figure 6: locked level (top-left), level 1 (top-right), and level 2 (bottom).

4 USABILITY TESTS

We conducted usability tests to study the user performances and perceptions of the game for improvement.

4.1 Methodology

To test the Physics game prototype, we assigned each participant to complete two game levels. Consequently, each participant had to earn two stars and achieve 50% of points in each game level. The participant may query QTut whenever he needs assistance to solve a task item.

The usability test can be described as follows.

1. The participant fills out a pre-questionnaire about his knowledge on physics and his exposure to games.
2. The participant plays with the Physics game. Meanwhile, the game system creates three types of logs: game level log summarizes the progress of the user at each game level, task log records the user performance in each task, and tutor log records the dialogs between the user and QTut.
3. The participant fills out a post-questionnaire about his subjective perception of the game, including QTut, the contents, the gameplay, and the enjoyment.

4.2 Participants

We recruited 10 participants (graduate and undergraduate students) for the tests (age mean = 26.6 y/o, age SD = ± 2.5, 3 participants were female) and each participant was rewarded with 5 Euros.

According to the pre-questionnaire responses, all participants have undergraduate levels of physics or above, except one participant who has high school level of physics; and classical mechanics (e.g., Newtonian principles) is the most familiar concept.

The participants play games 1-5 times a week (mean = 2, SD = ± 1) and a playing session lasts for 1 hour on average. Most participants play games for fun and identify themselves as occasional gamers. The pre-questionnaire also shows that notebook is the most frequent device for gaming among participants. This suits well to our proposed system.

4.3 Results

We divided the test results into two areas: the user performance based on the game log, and user subjective perception based on the post-questionnaire.

4.3.1 User Performance

The participants spent approximately 14.5 to 29 minutes to complete the game (mean = 19.8, SD = ± 4.7) (Table 2). The mean score is 120 points with a minimum of 90 points and a maximum of 150 points. The final scores of the first and the second participants are missing due to hardware problem during experiment. There is no significant difference on game time ($F(3,6) = 0.78$, $p = 0.55$) and final score ($F(3,4) = 4.81$, $p = 0.08$) between participants with respect to their prior knowledge. All participants retried level 1, whereas 2 participants retried level 2. This suggests that the participants were familiarizing themselves to the games at the first level.

Table 2: User Gaming Data.

User	Time (mm:ss)	Score (pts)	#Retry level 1	#Retry level 2	Prior knowledge
1	18:44	-	1	0	high
2	20:09	-	1	0	medium
3	25:24	90	1	0	low
4	14:56	120	1	1	medium
5	14:28	130	1	0	medium
6	15:33	110	1	0	high
7	14:46	130	1	0	high
8	17:54	130	1	0	very high
9	25:26	150	1	0	very high
10	28:25	120	1	1	medium
Mean	19:46	123	1	0.20	-
SD	$\pm$4:42	$\pm$17.53	0	$\pm$0.42	-

Table 3 shows all activities performed by the participants. Only one participant used features on Facebook (i.e., like/dislike and comment) due to privacy concern. All participants kept the QTut audio on, 5 participants asked some questions to QTut, and 1 participant changed QTut avatar. Scaffolding tools (calculator, ruler, and trigonometry illustration) were frequently accessed by all participants.

Table 3: User Activity.

Activities	# Participants
Like/dislike on Facebook	1
Leave a comment on Facebook	1
Turn on/off QTuts audio	0
Query to QTut	5
Change QTut avatar	1
Access competition table	1
Use calculator	10
Use ruler	10
Open trigonometry illustration	8

4.3.2 User Subjective Perception

Based on the post-questionnaire responses, the participants found QTut helpful. Nine participants preferred to have QTut synthesized speech since it helped them to learn better and to retain their attention. Likewise, the participants found QTut responses informative and QTut avatar pleasant (Figure 7). Five participants (who made queries to QTut) perceived QTut to be accurate (4.0/5 on a Likert scale).

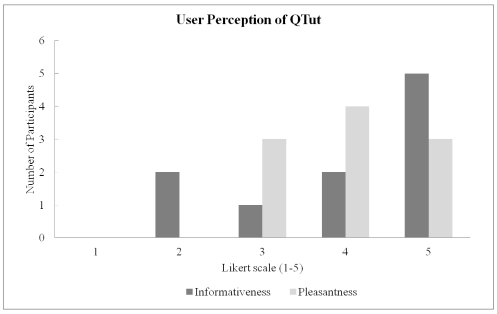

Figure 7: User perception of QTut's responses and avatar.

All participants agreed that they learned and/or recalled some concepts in physics: force, weight, friction, and torque. Eight participants claimed that they might understand the game without given any instructions (or mission) due to the icons and the GUI. This illustrates the expressive power of the GUI; and feedforward and feedback concepts were successful in delivering such GUI.

In term of the timer, 5 participants preferred to have a timeout since timeout challenges and encourages student to answer as many as possible. On the other hand, 4 participants preferred to have a time bonus since it constitutes positive feeling compared to timeout.

Figure 8 compares the average user perception of the game prototype to the game that they regularly play (the control). The participants perceived the Physics game prototype as significantly educational compared to the control ($F(1,18) = 22.785$, $p < 0.001$). Although the Physics game prototype was less entertaining compared to control, the difference is not significant ($F(1,18) = 1.056$, $p = 0.318$). In addition, the Physics game prototype offers somewhat equal challenges to the control ($F(1,18) = .051$, $p = 0.824$).

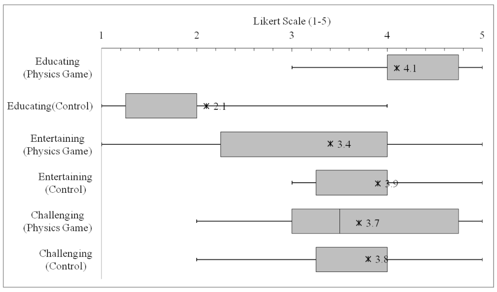

Figure 8: User perception of the Physics game against the control.

Positive feedbacks from the participants include good GUI (color and animation), helpful scaffolding tools (QTut, ruler, and calculator), interactive learning, hard but do-able problems, and enthralling game. In addition, the participants preferred some scaffoldings (ruler and calculator) to be always displayed instead of selectively displayed when necessary. Conversely, negative feedbacks mostly involve the learning materials, e.g., too many calculating problems.

5 CONCLUSIONS

In this paper, we have presented our work on designing a physics game to supports inquiry learning and retrieval practice using simulation and pseudo-tutor (QTut). The game was implemented as an online puzzle game that used driving questions to encourage students to explore the simulation. We addressed three challenges in designing the system: extensibility, scalability, and reusability. Consequently, we defined game levels and game format to cope with extensibility. Also, knowledge triplets were designed to represent QTut knowledge. The system was divided into modules to allow scalability and reusability. The game GUI was designed using feedforward and feedback concepts and grid system. Subsequently, usability tests on the game prototype were conducted to study the user performances and perceptions for improvement.

The results indicate the game as educative and moderately entertaining. The use of scaffolding (visual, auditory, and QTut) positively contributed to the game experience. Moreover, the game GUI expressed information well that made the game understandable, even with little instructions. However, our study can be seen as encouraging preliminary results and not as decisive proof of our concept due to the limited number of participants.

Future works will investigate the usefulness of the game for learning. Several game features can be further explored and optimized to better contribute to learning. For instance, comparing the game with other learning systems, e.g., computer simulation, can be useful to determine the effectiveness of the scaffolding techniques in the game. Enjoyment factor, which is equally important to learning, can be further studied. The enjoyment can be measured and subsequently correlated with the learning effects. Several frameworks for measuring enjoyment based on the flow theory (Kiili and Lainema, 2008; Fu et al., 2009) can be used for this purpose.

ACKNOWLEDGEMENTS

This work was supported in part by the Erasmus Mundus Joint Doctorate in Interactive and Cognitive Environments, which is funded by the EACEA

Agency of the European Commission under EMJD ICE FPA n 2010-0012.

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Automatic Updating of Computer Games Data Warehouse for Cognition Identification*

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Keywords: Cognitive Skill Mapping, Computer Games, Automatic Database Integration, Automatic Database Mining.

Abstract: This paper describes the algorithms (called OTEP_DW_auto) for automatically updating the integrated games data warehouse and cognitive profile data sources for purposes of identifying child's cognitive skill level. The techniques described in this paper represent an extension to the data integration engine adopted by an online product called "Thriver" developed by OTEP Inc. (Online Training & Evaluation Portal). OTEP focuses on using the Internet, natural playing environment for online computer games to give parents and care-givers automated opportunity to screen and follow their children's cognitive development. Current data integration efforts of the system when new games (such as speech games) are added or new cognitive skills matrix are added would require manual re-coding of the system which is a costly and time-consuming process. The cognitive skills matrix maps cognitive skills level of games player such as "basic reading level is good" to their games performance in comparison to the norms of other players. The proposed OTEP_DW_auto is capable of building the OTEP data warehouse schema automatically, thus seamlessly extracting, cleaning and propagating data from various data sources. It also provides a dynamic GUI-based interface for answering tens of frequently asked cognition-related questions.

1 INTRODUCTION

With the proliferation of hand-held devices such as computer laptops, tablets, and smart phones, there is increased easy access to online resources and video games. There is a body of research that points to unique learning habits of young people who prefer short visual explanations, to receive information quickly, prefer multi-tasking and non-linear access to information, have a low tolerance for lectures, prefer active rather than passive learning, and are kinaesthetic, experiential, hands-on learners who must be engaged with first-person learning, games, simulations, and role-playing (Junco and Mastrodicasa, 2007); (Oblinger and Oblinger, 2005); (Tapscott, 2009). Although playing computer and video games are largely seen as a distraction to learning, they are recognized as valid cognitive activities since they affect a player's ability to self regulate, make right decisions, and problem-solve ((Dance, 2003), p. 177).

The goal of this research is to use already available technology devices (computers and online video games) accessed by youth to identify children with learning differences that may be affecting their learning abilities (e.g., the acquisition, retention, understanding, organization of information). This research discusses an extension to an earlier system (Whent et al., 2012) for identifying a child's cognitive skill level called "Think-2-Learn" (presently renamed "Thriver"), created by OTEP Inc. (Online Training & Evaluation Portal).

Section 2 presents the related work on computer gaming, cognition and learning, OTEP's Thriver data warehousing and mining approach, and on some existing data warehousing schema integration approaches. Section 3 presents the new additional automatic data warehouse integration approaches being proposed for advancing the OTEP solution, including the automatic data warehouse schema integration algorithm, automatic querying and data cleaning algo-

*This research was supported by the Social Sciences and Humanities Research Council (SSHRC) and FED DEV/OBI and NSERC grants of Canada.

rithms. Section 4 discusses performance analysis of how games data can be effective in identifying cognition while section 5 presents conclusions and future work.

2 RELATED WORK

2.1 Computer Games, Cognition and Learning

Positive effects of playing computer games on cognitive development include improving visual intelligence skills which are useful in science and technology, and generally in such fields requiring manipulation of images on a screen (Subrahmanyam et al., 2000). Although other consequences of playing computer and video games have been studied (Martinovic et al., 2011) computer-based games may enhance hand-eye coordination, visual scanning, auditory discrimination, and spatial skills (DeLisi and Wolford, 2002). It has been stated that repetitive game playing may increase young children's working memory (Thorell et al., 2009), mental rotation accuracy (DeLisi and Wolford, 2002), and spatial rotation, iconic skills, and visual attention (Subrahmanyam et al., 2001). Playing the carefully and purposefully designed computer games may positively affect learning among children of wide range of ages (Subrahmanyam et al., 2000), (Martinovic et al., 2014a), (Martinovic et al., 2014b). This is because playing computer games involves integration of "touch, voice, music, video, still images, graphics, and text" (IBM, 1991), and can stimulate a variety of intelligences (e.g., linguistic, logical, spatial, kinaesthetic, musical), that may particularly influence development of literacy skills and ability to problem-solve.

2.2 Data Warehouse Schema Integration Approaches

A data warehouse is a historical, integrated, subject-oriented database storing data from multiple data sources in the one data warehouse schema (Han et al., 2011). Construction of a data warehouse is done through processes of schema and data integration of different data sources which involve data cleaning (Ezeife and Ohanekwu, 2005), data transformation and loading with periodic refreshing. A popular data warehouse schema approach is the star schema where there is a central fact table having foreign key attributes that include the main subjects of interest, the integration attribute, the historical time attribute and some non-foreign key aggregate measures of interest. Other descriptive tables in the data warehouse design using the star schema are dimension attributes for describing the foreign key attributes in the fact table (Ezeife, 2001). A measure such as score achieved during a game by a child can be calculated from a multidimensional model version of the data warehouse called the data cube (Ezeife, 2001). Existing schema integration approaches (Kern et al., 2011), (Fan and Poulovassilis, 2004), (Rahm and Bernstein, 2001) process some common steps during schema integration. The first step in integrating schemas (e.g., integrating schema1(Cust, C#, CName, FirstName, LastName) and schema2(Customer, CustID, Company, Contact, Phone)) is to identify and characterize these inter-schema relationships between the multiple data source schemas to be integrated. This schema element relationships can be identified automatically through integration approaches such as application domains, match operator, architecture for generic match, schema-level matchers, instance-level approach. Application domains approach integrates an independently developed schema with a given conceptual schema and requires semantic query processing. Once these schema relationships are identified, matching elements can be unified under a coherent, integrated schema or view. Match operator requires a representation for its input schemas and output mapping and needs to explore many approaches to match. For example, the result of calling Match on the two schemas above could be Cust.C# = Customer.CustID, Cust.CName = Customer.Company, and {Cust.FirstName, Cust.LastName} = Customer.Contact. Schema-level matchers only consider schema information, not instance data. The available information includes the usual properties of schema elements, such as name, description, data type, relationship types (part-of, is-a, etc.), constraints, and schema structure. Instance-level data can give important insight into the contents and meaning of schema elements. For example, a data-guide or an approximate schema graph can be generated automatically from XML documents. In (Kern et al., 2011) a framework for building logical schema for federated data warehouse from different data warehouse resources was proposed. The logical schema of the federated data warehouse is generated as a result of integration of components of data warehouses (the fact and dimension tables). The input to the integration process consists of several sets of fact table (F) with dimension tables (Dim) that are related to the fact table F through foreign key constraints. To integrate the data warehouses into one federated data warehouse, the algorithm begins with an empty fact table (F_output), and for each measure aggregate attribute in an input fact table F_input, it looks for a corresponding measure attribute and if it exists, it defines the mapping between these two attributes in the input and output fact table. If it does not exist in the output fact table, then, the new measure attribute is inserted in the output fact table and the mapping between these input and output fact table measure attribute is defined and inserted. Then, for each dimension table in the input data warehouse, D_input, it matches the foreign key attribute of the table with those of the output dimension table if this input dimension table exists in the output data warehouse and defines the mapping between this input dimension table and the output fact table. If the input dimension table does not exist in the output data warehouse, or none of its attributes match in schema F_output, then it adds the dimension table to federation schema F_output. In (Fan and Poulovassilis, 2004), a heterogeneous data transformation and integration system, named AutoMed, that offers the capability to handle data integration across multiple data models and supports a low-level hypergraph-based data model (HDM) was proposed. For any modeling language M, data source wrappers translate data source schemas expressed in M into their AutoMed representation, and for every construct of M there is an adds and a deletes primitive transformation which add to/delete from a schema an instance of that construct.

2.3 OTEP Data Warehouse Integration Approach

Whent et al. (2012) presented the OTEP system which uses online games to screen or assess children's cognitive skills in order to later suggest a learning plan that would be most suitable for their learning success. Thus, the paper described an approach for gathering and integrating the relevant data from (1) video games data, (2) cognitive skills and mapping data and to obtain a data warehouse schema called OTEP GamesDW. The input games data source that was integrated had then, 100 games that a child can play. The games data source containing information about each game, user's record of game plays, user information, game categories etc. were represented in about eight database tables. The second data source integrated into the OTEP GamesDW is the cognitive data source, which describes the cognition levels and their connections to the game instances in the first data source. The system used about 10 main cognitive categories such as Visual Processing, Processing Speed, Auditory Processing, etc., and two to eight sub cognitive categories (e.g., verbal output and written output as sub categories of processing speed). The integrated data warehouse has the following fact table with attributes from games data source and cognitive data source. FactTable(userid, gamid, gameseq, gameDB, gamelevelid, catid, normcogid, cogid, cogsubid, time-m, coglevel, gamescore, duration, tries); This fact table along with accompanying dimension tables can be used to answer queries like What are the cognitive norms (based on cognitive categories attached to the games) and game achievement norms (based on the average game play scores) for children who are 8 years old and who have difficulty reading for a reading game?. Currently, the schema integration is typically performed manually, perhaps supported by a graphical user interface, that is a tedious, time consuming, error-prone, and therefore expensive process. To provide automated support suitable for integrating new changes in the data sources as well as integrating new data sources such as those for connecting learning with both cognitive achievements and games play achievements, we proposed a generic, customizable implementation of the Match operator that is usable across application areas which makes it easier to build application-specific tools that include automatic schema match. Our proposed OTEP automatic integration approach is based on combining the application domains and schema-level matchers.

3 THE AUTOMATIC OTEP_DWH SCHEMA GENERATION APPROACH

3.1 The Automatic OTEP Model and Problem Addressed

In the first phase of OTEP Inc. (Online Training & Evaluation Portal) project (Whent et al., 2012), the data warehouse schema was built manually by the developers. Continuous manual data warehouse integration is tedious and time consuming because the database developer or the administrator spends a lot of time creating the initial schema of the data warehouse. In addition, there is need to keep monitoring any changes in all the corresponding database sources, or to integrate new data sources such as new games sources or learning data source to reflect the change and update the data warehouse schema. Thus, to have a more correct, effective and available data warehouse structure, this paper proposes advancing the initial OTEP system with the ability to do automatic data warehouse integration and refreshing to accommodate new changes in source schemas, or integrate new schemas. It also proposes an automatic querying interface for online analytical processing.

The existing OTEP model (Whent et al., 2012) measures a child's cognitive abilities through his/her performances in repetitive playing of a variety of games in different cognitive categories. The model accomplishes this goal by comparing the child's performance in these games with the performances of dynamically changing normalized performances (termed norms) of other children in similar comparison groups such as age, ethnic background, social background, learning or physical, etc. Thus, OTEP system uses data warehouse integration approach to integrate game playing database, cognitive inventory database, and other data sources such as learning inventory database and online analytical processing (olap) approach with multidimensional views (Ezeife, 2001) as well as data mining approaches for querying. The game playing database can also result from a continuous integration of various gaming sites.

3.2 The Automatic OTEP Data Warehouse(OTEP_DW_auto) Algorithms

The goal of this system is to automatically build, refresh and update the integrated, historical data warehouse of online games play records of children, their cognitive and learning characteristics. These data warehouses are used to screen or assess children's cognitive skills and later suggest a learning plan that would be most suitable for their learning success. This paper describes the algorithms for automatically integrating the relevant data from (1) video games data, (2) cognitive skills and mapping data and to obtain a data warehouse schema called OTEP_GamesDW_auto. In the future, other data sources will be integrated including the learning achievement data and third party data. The current schemas of the games data source and the cognitive data source with the integrated data warehouse are provided in this section. Three automatic algorithms for schema generation, view (querying) generation and data cleaning are presented.

3.2.1 The OTEP_DW_auto Schema Generation Algorithm

The input of the OTEP_DW_auto schema generation algorithm is the Database Name (e.g., Thrivergames, Discovery which are names of the database to be integrated automatically) which contains the connection parameters. After the connection to the database, the algorithm queries the table name sourceStructure

Table 1: A Segment of the sourceStructure Metadata of Two Data Sources.

field Name	field Type	field Size	field Constraint	field Source	field Table Name	field Table Type
user id	Number	20	primary key	Think2 Learn	wp_t2l _user	dimension
user login	Varchar2	20	unique	Think2 Learn	wp_t2l _user	
score	Number	10		Think2 Learn	wp_t2l _game_log	aggregation
duration	Number	10		Think2 Learn	wp_t2l _game_log	aggregation

which contains metadata information (consisting of all the attributes (fields) in the databases and their descriptions) about the two database sources. An example schema for the metadata table, sourceStructure is sourceStructure (fieldname: string, fieldType: string, fieldSize: integer, fieldConstraint: string, fieldSource: string, fieldTableName: string, fieldTableType: string). The description of the steps in the proposed Automatic OTEP_DWH schema generator algorithm are presented next. Step 1: If no data warehouse, called OTEP_DWH already exists in the server, then create an empty data warehouse structure called OTEP_DWH. Otherwise go to Step 9.

Step 2: Sort the table sourcesStructure which is given as input to the algorithm by attribute fieldTableName. Table 1 shows an example, illustrating the structure and contents of table sourcesStructure.

Step 3: Read all the attributes of the table (from fieldName of sourceStructure table) in the database for purposes of mapping to an existing attribute or adding to the existing schema.

Step 4: In this step the algorithm creates all the dimension tables of the data warehouse. The algorithm sequentially reads the value of attribute fieldName from sourcesStructure table as per step 3. It reads the table name of that attribute from fieldTableNameattribute as in step 4.1. It checks whether the table name is marked as dimension table in attribute fieldTableType as per steps 4.2 to 4.5. If the table name already exists in OTEP_DWH schema, then the algorithm adds the new attribute and maps it to the related dimension table. If the table does not exist in OTEP_DWH schema, then the algorithm creates the dimension table with the name of the value of fieldTableNameattribute concatenated with _dim string (to distinguish the dimension tables), the new created dimension table including the attribute as per step 4.4. The algorithm iteratively repeats step 4 for each attribute its tables marked as a dimension table until it builds all the dimension tables.

Step 5:Create the fact table named factTable. The fact table represents the central table of the star schema with major subject, integrated, and historical

attributes. For each primary attribute in dimension tables, the algorithm adds the attribute to the fact table as a reference (foreign key) attribute which refers to the dimension table.
Step 6:add the subject attributes which have a value subject in attribute fieldTableType to fact table factTable.
Step 7:Add the integration attribute to the fact table factTable. The integration attribute is used to distinguish the source of the database from which the original record was fetched.
Step 8: Add the historical attribute to the fact table factTable. The proposed algorithm adds the attribute name dateTime which stores the date and time of creation of the record in the fact table, factTable.
Step 9: Extract all table names and attributes from the source structure table that have fieldTableType value as dimension.
Step 10: For each dimension table, match the table name with given remote database tables to be integrated in the existing data warehouse DWH. We define the match operator with the keyword

```
{%users%, %games%,%collections%,%level%},
 and each keyword has subk-keywords
 for example user keyword has subkeywords
 {%info%,%profile%}.
```

Step 11: For each matched table, extract the data of all the attributes having primary key, and the data into the fact and corresponding dimension tables.

3.2.2 The OTEP_DW_auto View Generation Algorithm

In this phase of the OTEP project, a dynamic graphical user interface (GUI) which allows the end user to query and browse the contents of the data warehouse in different views was built. The interface is user friendly and has the flexibility to compose any kind of query on the data warehouse presenting the result as a view. The following are some queries that can be answered as views by the data warehouse. For this reason, we propose an algorithm to automatically generate the required view by the end user. Algorithm 1 shows the automatic view generator algorithm. Q1) list all students with their ages, source database, and number of played games for all the periods.
Q2) for a given student ID, list all the played games by the student including the completed levels, achieved score, number of tries, and duration.
Q3) for a given student ID, list all played games by student including respective main-category, respective sub-category, score, and derived performance.
Q4) view the matrix performance for a given student in each individual model.
Q5) view the required performance, achieved performance in a specific cognitive skill with a specific/all cognitive main category in a specific model for a given student.
Q6) For a given student ID, list all the played games by the student including score, compared to highest score, lowest score, and norm among all students who played the same games.

Algorithm 1. *(The Automatic OTEP View Generation Algorithm.)*

Algorithm OTEP_DWHview ()
Input: list of all parameter attributes fields (columns need to be shown in query result), condition criteria
Output: view containing the execution result of the query
BEGIN
1. Find the table name in OTEP_DWH data warehouse for each attribute in fields input
2. Create data query language (DQL) as a select statement
3. Concatenate the input condition to the query statement
4. Submit the query to the OTEP_DWH data warehouse and store the result
5. Return the result to the end user
END

3.2.3 The OTEP_DW_auto Data Cleaning Algorithm

Our extraction system faced a lot of challenges during extraction of data contents from each individual video game database source in order to load them into OTEP_DWH. This is because of the different formats and representation of the games data. In addition, it is due to the existence of different database schemas and structures. Thus, we implemented a cleaner algorithm shown as 2 for cleaning and extracting the data of interest and loading it in the right position in data warehouse. The OTEP system also keeps track of all the new modifications such as add, delete, modify table or attribute in database source.

Algorithm 2. *(The Automatic OTEP Data Cleaning Algorithm.)*

Algorithm OTEP_DWHcleaner ()
Input: data records of all database sources
Output: clean data loaded in data warehouse
BEGIN
1. Remove the white spaces of those data records have value of attribute gameStatus equals to completed
2. Remove all special characters and symbols such as {,}, /,[,],<,>,,;
3. For each attribute name located in OTEP_DWH, extract the next token which represents the value of attribute in

the right position in data warehouse
4. For the user_login attribute extract the userID, gender and age of the student because the value of the attribute is given in the format such as 111111_M_14 this means that the studentID=111111 is male (M) and 14 years old age.
END

4 PERFORMANCE STUDY AND USE OF OTEP SYSTEM

The goal of this paper is to propose computer science automatic data integration methods (algorithms) that are used to extend the OTEP system for identifying cognition through repetitive video game playing. Thus, a performance comparison is one which shows that the extensions provided by the new system are correct and more effective in integrating more data sources automatically and handling more complex queries. We shall provide in the next subsections discussions of the extensions provided by the system and details of how to use the OTEP system to correctly identify cognition.

4.1 Correctness of Extensions Provided by New OTEP System

An example automatic integration performed with our extended OTEP system has the ability to integrate more than one cognitive skills matrix model for map the video games performances of a player to cognitive skills levels. In the earlier OTEP system (Whent et al., 2012), only one cognitive matrix model, the Crouse model (Crouse, 2010) was used while the current system proposed in this paper allows integration of more than one model now including also using the Reed cognitive matrix model (Martinovic et al., 2014a). Each of the cognitive models provides both the cognitive classification model (called the cognitive matrix) and the cognitive correlation matrix (called skills matrix). The cognitive matrix model provides a method for classifying simple responsible video games into one of the main cognitive categories and subcategories. The cognitive skills matrix specifies the correlation between areas of cognitive processing and student achievement. For example, with the Crouse model, there are 6 main cognitive categories (such as auditory, visual, sequential rational, concept, speed and executive) and 2 to 8 sub categories such as (short-term memory for visual details, talking speed, etc.). The games in our repository are classified into a main cognitive category and subcategories so that our integrated data warehouse system can be used to gather for each player, the historical game play data such as scores achieved in each game, number of trials for each game level and the time needed to complete each game level. Our system computes the game play norm (average as norm and/or any other measures such as variance, standard deviation) of a comparison group (e.g., all 8 year old, all male players, etc.) so that the performance of the player is compared with this norm and their cognitive level could be identified with the cognitive correlation matrix model (called skills matrix) using a model such as Crouse's or Reed's. The cognitive skills matrix specifies the correlation between areas of cognitive processing and student achievement. For example, with the Crouse model used in (Whent et al., 2012), it is indicated that for cognitive skill of basic reading, in the 6 main cognitive categories of auditory, visual, sequential, concept, speed and executive, a player's basic reading skills is taken to be good if their computed game play record in auditory games is high (as determined using the bell shape and the norms and the standard deviations), visual is moderate, sequential is high and speed is high. The newly integrated Reed's model consists of 9 main cognitive categories and 43 cognitive subcategories.

Another example is that the existing system had been extended with this approach to move from 100 video to about 200 video games in its repository. Other usability features added include automatic querying capabilities with automatic views for a wide range of cognition-related queries.

4.2 How to Use the OTEP System

In our research we work with simple, single-player games that potentially target and measure the key cognitive skills in children and adolescents. In addition to carefully analyzing each game, we also look into the player's performance (e.g., time spent on task, repetition of trials, engagement, and use of hints), note the background information (e.g., grade level, age and gender), and acquire input from their parents and teachers. The list of cognitive skills is presented in a cognitive matrix at the Online Training & Evaluation Portal (OTEP Inc., Whent et al., 2012); it has 9 main cognitive categories (visual perception, visual attention, visual motor, auditory processing, executive function, memory, acquired cognition, social cognition, and emotional cognition) and 43 sub-categories (e.g., visual tracking, selective attention, problem solving, and semantic memory). Our interdisciplinary team uses two web sites; the portal for parents, Thriver.ca, and a site for gamers, ThriverGames.ca, which currently has 167 games.

The games are grouped according to the cognitive skills they employ, based on the cognitive matrix. This classification helps us to determine in which categories we are still missing games, and can also be used when suggesting to children which games to play next. We also invite a child's parents or caregiver to complete a survey about his/her learning style, behaviour, and his/her cognitive strengths and weaknesses. The survey and gaming information are recorded in a database suitable for searching and retrieving data, and producing reports. An enhancement of the software system (the web sites and a database) will use these data to create a personalized plan for the child with recommendations of which games to play next and other strategies that the whole family can use to support their child's cognitive development. These recommendations are based on our extensive literature reviews that are ongoing and will continue throughout this project. This system could be used under a variety of conditions (e.g., in school or at home), could be designed to provide feedback to the child, parent, or professional (e.g., teacher, psychologist), and could work under different models (e.g., behaviourist or cognitive model), based on the parameters selected by the user.

Our target population are 7-12 year olds and their parents/caregivers. There are three ways in which one could participate in our study: (a) as an online games player (contributing to a pool of normative gaming data, based on the playerage, grade level, and gender); (b) as a parent, who completes an online survey and enrolls the child to play games online (where the survey and gaming data are triangulated and a child's cognitive profile is created); (c) as a face-to-face participant in our controlled lab environment (where parents complete the survey and children complete cognitive and academic achievement tests, and are observed during selected game play to record engagement in gaming). Presently we are still collecting data in a controlled environment in which the child does NEPSY II (Pearson) test and plays 15 games that target the comparable cognitive skills as NEPSY II.

So far we have extended OTEP's repository of simple online computer games to 167 games and validated these games to determine (according to the cognitive matrix), the primary and secondary cognitive skills engaged in the players during each game (Martinovic et al., 2014a). We worked in parallel on: a) establishing a literature review in the area of playing simple computer games (i.e., single-player games that are relatively short and are high in activation of specific cognitive processing domains) and their relation to cognitive effects/gains among children, while putting specific emphasis on a design, reliability and validity of instruments and methods used; and b) investigating the feasibility of various methods for evaluating the relationship between games and children's cognitive skills. Based on our present data collection in the lab environment, we intend to establish correlation between: on one side–the child's cognitive skills and learning style, and on the other side–the child's games play data.

5 CONCLUSIONS

In this paper, we presented the extension made to our current work on the online product called "Thriver" developed by OTEP Inc. (Online Training & Evaluation Portal). OTEP video games source databases continues to grow and has grown from 100 to about 200 games whose records need to be integrated into the data warehouses for correct querying. Thus, the need to build an automatic schema and data integrator, view generator and data cleaner for continuous integration of new games and other data sources into the system. The OTEP system is intended to record players' scores to continuously assess and monitor their cognitive strengths and weaknesses with regards to the main cognitive categories. The Web based tool for identifying cognitive skill level is developed as an integration or data warehouse of a number of relevant data sources such as the cognitive skills categories data (which also changes as provided by the psychologists), games data (changing as more games are placed in the repository), player inventory data and so on. The integrated data are continuously mined, analyzed and queried for proper and quick assessment or recommendations.

We continue to work on extending the system: (a) increasing number of games; (b) increasing a reliability of categorization of the games by achieving an agreement between 2-3 scorers; (c) new cognitive matrix categorizations (for example, Crouse's or any other.) (d) developing a formula that will incorporate the features of the game (including differentiating the impact of different cognitive sub categories), the number of trials, the scores achieved and the time spent playing. Future work also include tracking children's cognitive development, proposing remediation in terms of games that may strengthen some cognitive abilities, and increasing validity and reliability of our approach.

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e-Competence
The Elderly and Competence in e-Learning

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Keywords: Lifelong Learning, Distance Education, Teaching/learning Strategies.

Abstract: The increase in population age is undeniable today. At the same time, technologies are increasingly present in daily tasks. In this scenario, the role of continuing education courses to enable showing the full development of the subject. E-learning can be one of these possibilities, since it covers a wide range of older people. Thus, it is necessary to discuss the necessary skills DL in the elderly. This research was developed in a virtual course of workshops with different themes for the elderly at the Federal University of Rio Grande do Sul in Brazil. From the results obtained in this study it was possible to map the skills of older students in a virtual environment. We list as interaction skills , autonomy , digital literacy , virtual literacy ; digital information ; virtual resilience , organization and cooperation. Therefore, we see the need for greater depth in relation to e-learning for seniors and what is required to allow for constructive action on this issue in this kind of education skills. Currently the increase of elderly led to questions and social change. Thus the results show the need to rethink new educational practices that may include older people in today's society.

1 INTRODUCTION

It is undeniable increase of population with advanced age. In Brazil the elderly population represents 20,590,599 individuals (IBGE, 2010). This high life expectancy provides social and especially educational changes.

Continuing education is a right of the population. A possibility of providing social inclusion and lifelong learning is through digital inclusion. This type of course can awaken and engage the elderly to explore the digital world, encouraging them to experiment, revise, repeat, construct, deconstruct and share experiences. Many researchers have been conducted in this field allowing the formation of a significant number of elderly in the use of technologies of information and communication (ICT).

In this panorama, and from the need to find new offers for this audience, offering online courses in different subjects is shown as innovative and feasible for the elderly. This modality involves continuing education and the use of technology and ultimately proves as a rich source of possibilities for a different audience that has social, emotional and motivating characteristics to learn and build new knowledge.

There are few studies that discuss the e-learning and the elderly (Reis, 2006), which provides questions and the need to delineate what would competences in this public virtual courses.

From this scenario, it started at the Federal University of Rio Grande do SUL/UFRGS, Brazil, offering virtual classes specifically for the public aged 60 years or more. In 2012 was offered in the state of Rio Grande do Sul/Brazil course "QualiViE - Quality of Life: Virtual workshops for active aging". The QualiViE was composed of six workshops. Each workshop had a subject of interest to older. These workshops were taught by specialist teachers. Each workshop lasted two weeks in virtual form. These were offered in virtual mode. Seniors who participated in the workshops participated in discussion forums, chats and activities. Data collection was conducted from the participation of older persons in workshops, through questionnaires and interviews. These data allowed discussing the necessary competences in Distance Education for the elderly. Therefore, the aim of this paper is to investigate what are the skills necessary for the elderly to participate effectively in online courses.

Then we will address the theoretical framework regarding the skills, the elderly and ICT

2 SKILLS: SHARES AND POTENTIAL OF THE ELDERLY IN E-LEARNING

Reflections on skills in recent years have increased significantly, which caused the dissemination of research, publications in journals and books that discuss the definition. However, the research conducted on the subject is not of an educational character, since it has started in the business.

In educational terms, Perrenoud (2000; 2002) began discussions about working with competencies in education, where he resumed the panorama of changes resulting from technological advances and what are the actions needed to address them. Concerned about the pedagogical aspects and development of skills Zabala and Arnau (2009), Coll and Monereo (2010) also discuss the same topic in education.

From the discussions in the literature and related research, this article will use the concept that defines the competencies as a set of Knowledge, Skills and Attitudes (named KSA), which provide subsidies enough to the individual to face situations and solve problems that emerge during the process of teaching and learning (Behar, Ribeiro, Schneider, Silva, Machado, Longhi, 2013).

Thus, it is necessary to think about the use of ICT at all levels of education and skills necessary for an effective and constructive use, especially with a different audience as the elderly. Therefore this is inevitable in this panorama to integrate in the concept of competencies few features that put into action the elements of the KSA. For this, Behar, Ribeiro, Schneider, Silva, Machado, Longhi (2013) lists three features: a) Support resource: it's biophysiological, refers to the body and its structure, b) Evolution resource: refers to creativity, which in a Piagetian perspective is considered the evolution levels of knowledge c) Mobilization resource: considers the role of affectivity in the construction of knowledge.

Some research has outlined the necessary.skills in using ICT. The European Union, supported by the European Commission and Council of Ministers, set up cyberskills, or e-competences for the XXI century. Based upon the justification of the changes arising from technology, was created the "European e-Competence Framework", a document that cites 36 skills needed in a corporate vision (CWA, 2010).

Discussing the same topic, different skills are cited for the use of ICT, as the case of information skill, knowing how to use the information in a given context (Dudziak, 2003; Bawden, 2001), digital skill in which the user must know to conduct digital research (Santos, 2009), among others as digital literacy and virtual skill. In this perspective, some skills can be listed in relation to the use of digital tools in e-learning:

- Digital fluency: goes beyond knowing how to use ICT, but it's knowing how to create meanings to this subject in order to provide permanent learning (Resnick, 2002; Takahashi, 2000; Machado, Longhi, Behar, 2013);
- Digital literacy: is the use of basic skills in reading, writing and mathematical problems as a way to understand the content and everyday relationships developed in e-learning (Kirsch, 1993; Machado, Behar, 2013);
- Interaction: refers to the interrelationship between teacher/student in e-learning involving interpersonal and intrapersonal relationships (Moore, Kearsley, 2008). In this competence the mobilization resource of affection is essential because it allows the student to a self-analysis to interact with colleagues and teacher shamelessly.
- Cooperation: is the competence that instigates forms of interpersonal relationships through teamwork towards a common goal, through digital technologies (Machado, Longhi, Behar, 2013);
- Autonomy: is the ability of self-guiding and refers to self-responsibility and self-organization in DL (Mattar, Maia 2007; Moore, Kearsley, 2008; Litto, 2010);
- Organization: it is established by ordinance, structuring and systematization of time, available materials, information and group work in virtual (Machado, Longhi, Behar, 2013);
- Communication: there are two styles of communication: oral and written (Villa, Poblete, 2010);
- Oral communication implies the ease and effectiveness of communicating ideas, feelings, and knowledge through the spoken words. This is required for video conferencing or other tool that requires user speech. Written communication refers to the ability to convey ideas, feelings and information through writing, including the use of support as graphics, illustrations and more. This is essential, since most tools of e-learning uses this type of communication;
- Virtual resilience: refers to the need of knowing about limitations and reassessment

regarding the attitude to continue learning in online mode in order to face the new (Machado, Behar, 2013);

• Informational: initially was linked to the search for information. The term is widely used by American librarians regarding the search and use of information (CWA, 2010). In recent years incorporated the use of technology in support of this research. But it is clear that research in digital media should be differentiated from the usual research in physical libraries. Therefore, refers to search and access information efficiently and effectively available in the digital medium.

Thus, this study demonstrates the importance of enhancing regarding to the skills of the elderly in distance learning and its importance in the society of information and knowledge.

In this scenario the search was conducted by research related on skills, the elderly, continuing learning and the use of ICT. Few studies were found and are generally searches or reports on how to assess competence in the elderly in legal terms. That is regarding the older person being able to keep or not active in daily activities (Willis, 1996; Widdershoven, Berghmans, 2002; Law, Yau, Gray 2012).

In terms of communication skills of the elderly, Underwood (2010) challenged the studies reporting the high linguistic decline. When there are really problems of expression, the elderly seek to communicate affectively (gestures, facial and body expressions, etc.).

Other references found not clearly pointed the definition of competence and its involvement in the continuing education of this public. Machado and Behar (2013) published a survey which showed eight competencies for older students in virtual courses, including: virtual resilience, digital fluency, autonomy, virtual literacy, organization, cooperation, interaction and communication.

Therefore, this perspective asks what skills are needed in the elderly to participate in online courses. To elaborate on the subject, the following will detail the methodology used to achieve the mapping skills of elderly people in e-learning.

3 MATERIAL AND METHODS

This research was developed in a quantitative and qualitative premise focused on case study. The investigation was built on a theoretical and practical approach to enable an immersion of the researchers to collect the data.

In 2011, work began on the development of an extension course "Introduction of DL for seniors" with the goal of empowering the elderly in the use of virtual tools such as virtual learning environment (VLE) and its functionalities and as learning objects (LO) built. The LO concept adopted is Behar, Macedo, Souza, Bernardi (2009) who considers any digital material with educational purposes.

During the year of 2012 it was offered the virtual course "QualiViE - Quality of Life: Virtual workshops for active aging". Altogether, there were 15 individuals who participated in the workshops. In this course were offered six workshops: Workshop Soundtracks Composition (Figure 1), Color Workshop (Figure 2), History and Memory Workshop (Figure 3), Workshop of Physical Therapy (Figure 4), Spanish Workshop (Figure 5), Photography Workshop (Figure 6). All workshops are taught by specialist teachers in each subject worked. Classes were taught in Portuguese, except Spanish. The duration of the workshop was two weeks. The classes were where we used virtual interaction and communication tools. LO was also shown in the figures.

Figure 1: Interface of LO workshop of Soundtracks Composition.

Figure 2: Interface of LO Color Workshop.

All workshops had two weeks in length, being only the first class live and the rest virtual. The only exception was the Spanish workshop that was offered lasting four weeks for its complexity in content. These were developed by expert teachers in the same areas, these being the ones who built the LO, activities and content covered. For classes we used the virtual learning environment (VLE) ROODA - Learning Cooperative Network (https://ead.ufrgs.br/rooda/) (Figura 7). This environment has 26 features, from these, were used during the workshops QualiViE: Forum: enables asynchronously discussion on a particular theme; Diary: place to express their feelings in written format; Chat: place for synchronous interactions; Webfolio: allows posting activities and teacher feedback on them; Library: allows sending supplementary class materials; Tab Lessons: posting place for the activities content; RoodaPlayer: functionality for viewing videos online and A2: form of synchronous Messenger.

Figure 3: Interface of LO History and Memory Workshop.

Figure 4: Interface of LO Workshop of Physical Therapy.

Figure 5: Interface of LO Spanish Workshop.

Figure 6: Interface of LO Photography Workshop.

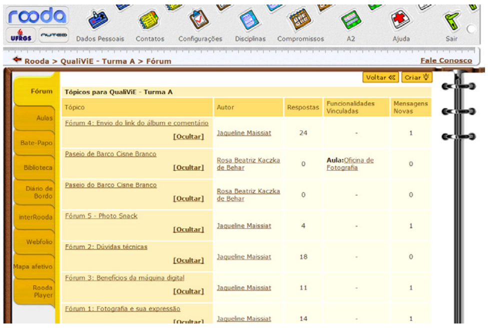

Figure 7: Interface of VLE ROODA.

In order to cover the purpose of this article, identifying the skills of the elderly in virtual, it was used a triangulation of methods for data collection: observation, interview and questionnaire and technological production. The observation, interviews and questionnaires occurred during the course QualiViE. In order to collect the information of the technological production it was used digital tools exerted by the elderly in VLE ROODA.

Therefore, for the quantitative data analysis it was used frequency distribution represented in percentage and mean. The analysis of qualitative data was achieved by means of content analysis, including critical or hidden understanding of communication. To do so, we used the steps suggested by Bardin (2010) in relation to content analysis. Thus, the following will treat the data collected during the research to enable understanding of skills, elderly and distance learning.

4 ANALYSIS AND DISCUSSION OF COLLECTED DATA

From the data collected in this research defined the profile of older people in e-learning and define the necessary skills in virtual mode.

The study subjects were 15 elderly with a mean age of 67 years, being two males. In relation to education, predominance of college degree (44%), followed by school (38%). These data indicate the predominance of a public with high education, what will distinguish this group from the rest of Brazilian elderly.

Considering the development of class planning the elderly showed that the teacher should consider mainly difficulties and skills that students will find in technology tools (Figure 8). It was noted during the workshop that one of the great difficulties of the students was the use of digital technologies, including VLE itself by still lack of knowledge enough to dexterity in using them. This evidence shows how important are Digital Fluency competence and Virtual Literacy competence.

Although it was performed many tutorials and videos related to digital tools, the elderly prefer to contact the teachers or instructors of the workshops. This denotes how the affective resource of competences is critical to this audience. According to the testimony of the elderly we can analyze that they could evaluate the preparation of teachers for the classes considering the potentialities and limitations of the student: "What I find most important in any workshop for seniors is the patience of the teacher with the students because we are slower".

Digital fluency and Digital literacy are important in this type of course, since before knowing the ease using of this technology is important to be literate and critically understand the usage of it.

With seniors this literacy requires an earlier competence called digital literacy in which the subject should have the first learning in the use of ICT and further develop digital fluency and literacy necessary in virtual courses for this audience.

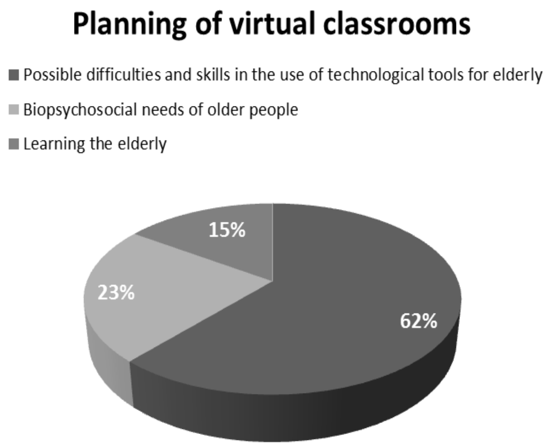

Figure 8: Graph of planning of virtual classrooms.

VLE ROODA, as already pointed out in this article, was used in the interactions between teachers and students, which makes it necessary to investigate the difficulties encountered in its use. Therefore, regarding ROODA tools the students had more difficulties with RoodaPlayer and Chat. The RoodaPlayer functionality is coupled to VLE ROODA where you can play video available on internet sites.

The difficulty pointed out by the students is mainly due to the fact that it is a new tool for the course and also due to technical difficulties in the operation of it since it was still in testing phase. The other features were evaluated with more difficulty according to needs (activities and content) that teachers used in each workshop.

In addition, elderly showed that they prefer communication tools (84%) in virtual courses. These data show the importance of developing a Communication Competence with this audience.

Communication is primordial in online courses, both orally and in writing. For seniors the two communications are important and complementary. Communicating in virtual requires the older audience know to "listen" and know the time to respond and their forms, since the virtual communication is different and unknown to the elderly.

Forum was the ROODA tool pointed as the most used during the workshops. Each forum (totaling 11) had an average of 15 students' participation. However, this participation was limited to only respond to the teacher and not interact with colleagues. So in this scenario would be important to develop the Interaction Competence, since that public is not accustomed to using the technology to keep in touch with each other, much less to express themselves emotionally and create / maintain virtual social ties.

Regarding activities, the elderly showed to prefer simple activities that use virtual resources and enabling research. The workshops that used unknown tools were the most valued, since they were more practical and useful for their everyday. They pointed out that the long activities were discouraging during the workshops.

The workshops that used the social network Facebook or a text editor, have not been evaluated positively because it was a tool known and learned by the elderly. According to the testimony of one of the elders: "We really didn't have Spanish classes, we only fill in the blank portion of a song and then sing".

Activities requesting conducting research were well evaluated, as the research on specialized sites, as those needed to recall historical facts of the subjects involved. The workshop of History and Memory, for example, dealt with the past historical issues of the elderly which generated a lot of movement both in family and friends to collect information such as the internet to supplement the data. So in this prism two skills are important for the elderly: Digital Information Competence and Competence of Autonomy.

Building informational competence in older audience requires a collaborative effort between the digital fluency and literacy, as it the (re)learn how to search. Unlike the elderly were accustomed, virtual research requires knowing to define objectively what you want, select and analyze in more detail the information available on the internet. And Autonomy should be encouraged by the teacher, tutor and monitors, mainly because students were not accustomed to the type of virtual classroom.

Asked about the timing of the activities, students reported it should be of three or more days for each task (46%). This evidence corroborates with other studies which show the need for a longer time to achieve these activities, both in classroom courses and virtual (Oliveira, Oliveira, 2007; Machado, 2007). These data are confirmed by the testimony of the elderly: "I thought the time very short, it could have been two weeks with two virtual classes".

The Organization Competence in this context is relevant, since the elderly - because they are mostly retirees - no longer have the accuracy in time and tasks deadlines that require greater dedication. The organization is critical in virtual courses and one of the main factors that hindered the elderly during classes, because many forgot to perform the activities or didn't schedule classes which caused their absence.

The format of the media pointed out as preferential by the elderly is printed, even in virtual courses (46%). Even with virtual activities they prefer to receive them in print, which shows the need for the security of paper, which is a form of technology known by them.

A surprising result was that in relation to the dynamics of activities, since 57% of students indicated they prefer to work individually. Among the reasons was that "Because everyone can do at the time we want or can at our house". Another elder said: "Because the elderly can do the activities when available". Complementing: "You can search more". Therefore refers mainly to issues of availability of participants to combine schedules (virtual and presence). Thus, developing Cooperation Competence is important, but we wonder how far it is interesting to the elderly. The elderly showed that there is no exchange between colleagues. Therefore, the cooperation competence can be considered cross and not general jurisdiction. It is noteworthy that this is a particular study in a small group of older people. Each group of older students has its social and cultural profile that should be considered when talking about competence.

Regarding the language activities, they showed a preference for the combination of text and image (87%). Although the workshops work with audiovisual content such as video and music still textual language is chosen by the elderly. According to the testimony of the elderly: "Its page was very good, attractive and without that figure drawing, which I found ridiculous of other workshops, with nothing to do with the rest", "Every technological feature that was shown was prepared for elderly". From these statements we can see that the language used by teachers is constantly evaluated by older students and they have criticisms concerning the form and format of the same.

The elderly showed that the content should be challenging and make them search and supplement their learning (92%). These data show that despite the older student be academically educated in the traditional perspective of memorization, they prefer building knowledge activity which becomes meaningful to their lives.

To finish, we asked a general evaluation of the workshops, in which the elderly showed a high satisfaction, followed by states of happiness and sadness. These data show that there was the construction of the Virtual Resilience competence, once they knew to face the new and continue to participate in virtual workshops.

Although the evaluation is positive, the experience in virtual workshops, students still prefers courses that combine presence and virtual classroom. According to the testimony of one of the elderly: "The presence classroom is very complete and enlightening and when I have doubts the virtual is also important". So we can see that older people are prepared to participate in online courses, but it is up to the managers and teachers of this type of course to plan adequately to meet the demands of the target audience.

5 CONCLUSIONS

The data collected and discussed in this article denote a profile of elderly active and who wants to participate in courses for continuing education. From the survey data and compared with those described by Machado and Behar (2013), it was possible to map the primordial competences in virtual courses for seniors.

So it was listed seven essential skills: Interaction, Autonomy, Digital Literacy, Virtual Literacy; Digital Informational; Virtual Resilience and Organization. From the reflection based on data the Cooperation Competence was not outlined as a key to that public, since depending on the profile of the students it will not be considered relevant in virtual interactions.

The Digital Informational competence was one of the highlights of this research, since the students indicated the need for them in activities that foster research, investigation, contradicting the view that courses for this audience should follow traditional lines of education. The Cooperation Competence, from the data collected, was considered transversal, once the public pointed out that prefer to work individually. Individuality is very present in the elderly, for different issues, ranging from the loss of loved ones (friends) to the abandonment from the family.

It should be noted that this study was conducted with a peculiar group of seniors, where the profile denotes subjects who want enhancement and new learning, and want to use ICT in their daily lives. This kind of group of elderly specifically does not allow a generalization of skills regarding older audiences of Brazil, mainly by financial difficulties or lack of education. Therefore, there must be other skills, mainly the transversal, in order to meet the different audiences that are around the world.

The data discussed here are positive for the application performed. According to the testimony of one of the elderly: "All elderly who want to stay active should do virtual courses. Old age is the future of everyone, so it is important courses that stimulate the creativity of older people". Thus, there is the need for greater depth in relation to e-learning for elderly or disclosure of this type of education courses for older people. With the rise of older people is up to everyone involved in education to rethink new practices that can effectively include the public in this society that is constantly changing.

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Second Language Learning in the Context of MOOCs

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Keywords: Second Language Learning, Corpus-based Language Learning, English for Academic Purposes, MOOCs, FLAX, Open Educational Resources.

Abstract: Massive Open Online Courses are becoming popular educational vehicles through which universities reach out to non-traditional audiences. Many enrolees hail from other countries and cultures, and struggle to cope with the English language in which these courses are invariably offered. Moreover, most such learners have a strong desire and motivation to extend their knowledge of academic English, particularly in the specific area addressed by the course.

Online courses provide a compelling opportunity for domain-specific language learning. They supply a large corpus of interesting linguistic material relevant to a particular area, including supplementary images (slides), audio and video. We contend that this corpus can be automatically analysed, enriched, and transformed into a resource that learners can browse and query in order to extend their ability to understand the language used, and help them express themselves more fluently and eloquently in that domain.

To illustrate this idea, an existing online corpus-based language learning tool (FLAX) is applied to a Coursera MOOC entitled *Virology 1: How Viruses Work*, offered by Columbia University.

1 INTRODUCTION

Massive Open Online Courses (MOOCs) are becoming popular educational vehicles through which universities reach out to non-traditional audiences. They are generally offered by English-speaking universities in the US and UK, and proponents often express an explicit desire to reach out to other countries and cultures. For example, Coursera aspires to provide a "meaningful learning experience for the millions of students around the world who would oCtherwise never have access to education of this quality" (Ng and Koller, 2013). Clearly, many MOOC students will encounter a language barrier during their study. Moreover, they will be strongly motivated to improve their knowledge of English for Academic Purposes (Dudley-Evans and St. John 1988); (Hyland, 2006) as it is used in the MOOC's subject domain.

The use of domain-specific corpora is a growing trend in language teaching and learning (e.g. Gabrielatos, 2005). Most corpora are based on particular domains, genres, or collections of certain types of document from which recurrent phrases and grammatical patterns can easily be retrieved (Stubbs and Barth, 2003). Among other aspects of language, a corpus provides an excellent context in which to study collocations, a notoriously challenging aspect of English productive use even for quite advanced learners (Bishop, 2004); (Nesselhauf, 2003).

We have developed an automated scheme called "FLAX" that extracts salient linguistic features from academic text and presents them in an interface designed for second-language students who are learning academic writing (Wu and Witten, 2013). The design is guided by several common ways of utilizing corpus technology. An extraction method is included that identifies typical lexico-grammatical features of any word or phrase in a corpus. Collocations and lexical bundles are automatically extracted; students can explore them by searching and browsing, and inspect them along with contextual information. FLAX also presents learners with common words, and academic words, hyperlinked to their usage and collocates in authentic contexts.

Typical MOOCs constitute a vast corpus of multimedia information, consisting predominantly of text but supplemented by images in the form of slides, audio, audio transcripts, and video; all (usually) in the English language. This paper argues that the very same corpus, pre-processed appropriately and presented in a different way, provides a focused resource that allows second-language learners to improve their linguistic knowledge in the domain addressed by the MOOC. (It is also helpful for native speakers of English.)

This paper uses as an example a Coursera offering entitled *Virology 1: How Viruses Work*, from which we have built a FLAX collection. We illustrate in the next section how this resource has been augmented for language learning, and then review how learners can use it to explore language usage. Having established a specific context, we elaborate our position by showing how this approach might be used to facilitate language learning, and what organizational and teaching structures would be suitable to put such a proposal into practice.

2 BUILDING THE COLLECTION

2.1 Selecting and Preparing Materials

Vincent Racaniello of Columbia University created *Virology I* from lectures that were popular across a range of web channels, including iTunesU and YouTube, before being imported into the Coursera MOOC. These lectures, along with Racaniello's weekly podcast *This Week in Virology*, his academic *Virology* blog, and articles related to his virology courses, are published under a Creative Commons Attribution licence.

All these resources were pre-processed before being built into FLAX collections. The lecture transcripts underwent simple editing, including division into subsections, and were reformatted into manageable chunks as HTML files to decrease cognitive load when listening and viewing. Scientific images and their labels from the lecturer's PowerPoint slides were re-formatted for readability.

2.2 Building Digital Library Collections

The FLAX Virology collection has the four components listed in Table 1. Textual documents are searchable, and browsable by title. Videos, audios and images are embedded within the document.

Table 1: Number of items in the collection.

Podcast audio transcripts	130
YouTube video lecture transcripts	110
Virology blog posts (lectures)	280
Open Access reference articles	40

We use the Greenstone digital library system, which is widely used open source software that enables end users to build collections of documents and metadata and serve them on the Web (Witten et al., 2010). The linguistic enhancements described below are all extensions to Greenstone.

3 AUGMENTING TEXT FOR LANGUAGE LEARNING

FLAX takes text documents, automatically extracts important language components—such as academic words and their usage patterns, key concepts, collocations, and lexical bundles—and presents them in way that draws the attention of students and gives them opportunities to encounter these components in various authentic contexts.

3.1 Words and Usage Patterns

The lexico-grammatical patterns of each word in the collection (excluding *a*, *an* and *the*) are extracted and grouped by position in sentence—near the beginning or in the middle—because these provide different views of the word's usage patterns.

For sentence-initial fragments, the part-of-speech tags of the opening words (except for conjunctions) plus one word following the query term are used to generate patterns. For mid-sentence fragments, the query term's syntactic type—verb, noun, adverb, or adjective—is used to select a stretch of text surrounding the query term, whose tags are used as patterns.

3.2 Key Concepts and Definitions

FLAX connects to the Wikipedia Miner tool to extract key concepts and their definitions from Wikipedia articles. Milne and Witten (2013) describe the method used to relate words and phrases in running text to Wikipedia articles. First, sequences of words in the text that may correspond with Wikipedia articles are identified using the names of the articles, as well as their redirects and every referring anchor text used anywhere in Wikipedia. Second, situations where multiple articles correspond to a single word or phrase are disambiguated. Third, the most salient linked (and disambiguated) concepts are selected to include in the output.

For example, *intracellular parasite*, *cells*, *organism*, *genome*, *nucleic acid*, … in the article

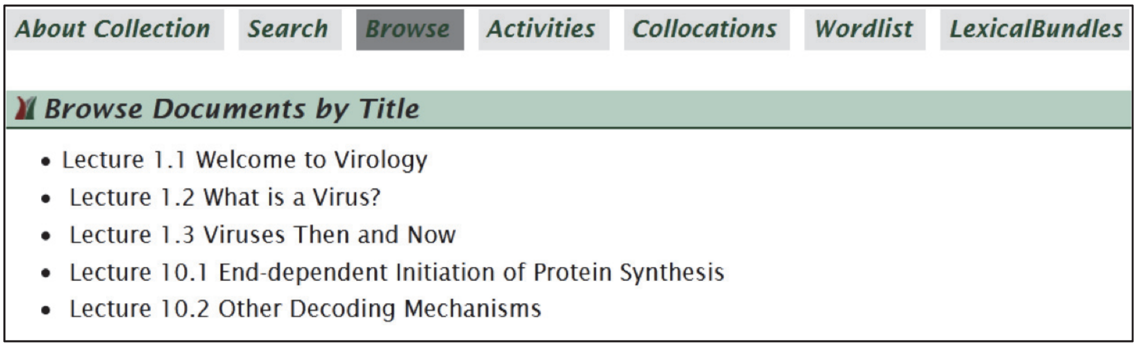

Figure 1: Main page of the Virology collection.

titled *What is a Virus* are identified as Wikipedia concepts. This definition for *genome* is extracted: “In modern molecular biology and genetics, the genome is the entirety of an organism’s hereditary information.”

3.3 Collocations and Lexical Bundles

The importance of collocation knowledge in language learning has been widely recognized. Hill (1999) observes that students with good ideas often lose marks in academic essays because they do not know the four or five most important collocations of a key word that is central to what they are writing about. Student text tends to be cumbersome and error prone because of insufficient collocation knowledge. The *Virology* collection contains massive, high-quality resources that help students build up collocation knowledge within the area.

We focus on lexical collocations with noun-based structures verb + noun, noun + noun, adjective + noun, and noun + *of* + noun, because they are the most salient and important patterns in topic-specific text. The system first assigns part-of-speech tags to words in the text and then extracts word combinations that match syntactic patterns. These extracted collocations are grouped by pattern and sorted by frequency.

“Lexical bundles” are multi-word sequences with distinctive syntactic patterns and discourse functions that are commonly used in academic prose (Biber and Barbieri, 2007); (Biber et al., 2003; 2004). Typical patterns include noun phrase + *of*, prepositional phrase + *of*, *it* + verb/adjective phrase, *be* + noun/adjective phrase, and verb phrase + *that*. Such phrases fulfil discourse functions such as referential expression (framing, quantifying and place/time/text-deictic), stance indication (epistemic, directive, ability) and discourse organization (topic introduction and elaboration).

To help users explore lexical bundles, FLAX extracts all short phrases that appear in the collection and sorts them by frequency. We chose four-word phrases because at any rate, this is the length of discourse bundle that appears most often in the literature. Bundles at the beginning of sentences (“head bundles”) are treated separately from ones in the middle (“middle bundles”).

4 HOW LEARNERS EXPLORE LANGUAGE USAGE

FLAX provides learners with simple interfaces to explore language features extracted from the course material. Learners can encounter and inspect words in their original context, or search for them by simply typing a word of interest, or browse them. Language activities built from course material reinforce what they have learnt.

Figure 1 shows the main page of the *Virology* collection of blog posts, which in fact correspond to lectures (this page is the same for the other three collections). The buttons at the top (*Search*, *Browse*, *Activities* etc.) link to language features described in earlier sections.

4.1 Exploring Articles

Users view articles by clicking *Browse* and selecting the article’s title. Each article has four different views. One contains the original text, and students can watch or listen to the accompanying video or audio. The other three draw students’ attention to the language features described above.

The *wordlist* view allows learners to analyze the range of vocabulary used in the article. It highlights the most frequent 1000 and 2000 words, taken from wordlists used in language teaching (West, 1953); academic words included in the list by Coxhead

(1998); and keywords. Clicking a highlighted word leads to a page that shows all sentences in the collection containing that word. Keywords (identified by the TF-IDF heuristic commonly deployed in information retrieval) are shown in the *keyword* view. The user can control the system's selectivity by adjusting a slider to reveal more or less keywords.

The *Wikipedia* view relates the terminology used in the article to the Wikipedia, highlighting concepts that are defined there to helps learners grasp their meaning. Clicking any highlighted phrase in the document brings up its definition, hyperlinked to the Wikipedia article itself; followed by a list of related topics in Wikipedia that can also be clicked.

The *collocation* view allows students to examine lexical compounds that occur in the article, divided into collocations that involve adjectives, nouns, prepositions, and verbs. Collocations are highlighted in the text to help students notice them and study their context. The system makes it easy for learners to study collocations in different contexts by connecting to two external collocation databases that are built from text in the British National Corpus, and from Wikipedia articles.

4.2 Search and Browsing

The *Search* button in Figure 1 displays usage patterns or collocations of a particular word. For example, one can study the patterns of the word *sequence*, a common academic word in the *Virology* collection, under <u>verb + *sequence* + *of*</u> and <u>verb + *sequence* + *that*</u> clause; or collocations of the word *virus*, the most frequent word. Collocations are grouped by syntactic pattern, e.g. <u>noun + *virus*</u>, <u>verb + *virus*</u> and <u>noun + *of* + *virus*</u>, and sorted by frequency. For example, the most frequent <u>noun + *virus*</u> or <u>*virus* + noun</u> collocations are *virus particle(s)* and following by *influenza virus*, *rabies virus*, *tobacco mosaic virus*. Clicking one reveals how it is used in context.

The *LexicalBundles* button lists bundles used at the beginning and in the middle of sentences under separate tabs. Clicking a bundle show the contexts in which it is used. In this collection, the most frequent bundles are conversational such as *And you can see*, *And this is a*, which indicate the spoken nature of this collection.

4.3 Language Activities

FLAX provides a series of language activities, accessed through the *Activities* button, that focus on words, collocation, sentence or article structures and concepts related to the topics. Each activity has a teacher's interface and a student interface. In the former, language teachers and instructional designers developing MOOC support can select parameters for exercise creation, and provide hints for students. The exercises are generated automatically, and can be reviewed and modified to discard undesirable language choices before presenting them to learners.

There are many activity types: here are two. *Cloze* ("fill-in-the-blanks") activities are widely used to test knowledge of vocabulary and syntax, as well as reading comprehension. Words are removed from an article and students must re-insert them. The target words can be content words such as nouns, verbs, adjectives and adverbs; or function words such as prepositions, pronouns, conjunctions and auxiliaries; or Wikipedia concepts that have been identified automatically as sketched above. To create a Cloze activity one selects an article and then decides whether the system should omit words based on a specified gap size, or specified parts of speech, or Wikipedia concepts. Images, audio and video that accompany an article can be added into the exercise at the teacher's discretion.

In a *Completing collocations* activity, certain words are again omitted from a document and users fill in the gaps. Here, however, missing words are chosen from collocations that have been identified in the document. FLAX chooses sentences, and highlights selected collocations. If the paragraph contains preceding and following sentences, they are shown as well, to provide context. Many teachers prefer to focus on certain types of collocation, e.g. <u>noun+ noun</u>, <u>adjective + noun</u> or <u>verb + noun</u>. This helps learners focus on sets of words that share similar meanings but have different usage (e.g. *problem* or *issue*) or word combinations specific to a topic (e.g. *virus infection* or *influenza virus*).

5 DISCUSSION

MOOC participants register for educational courses; they do not sign up as language learners. Columbia's virology MOOC is based on mastery learning (Bloom, 1984). Course content builds from week to week, and learners must master previous content before progressing. Assessments match this philosophy: weekly quizzes build towards a final exam.

Of course, the world of MOOCs is fluid: a great deal of experimentation is taking place in terms of the educational theories and approaches that underpin the range of courses hosted by different institutions. Critics of methodology and terminology divide MOOCs into two camps (Daniel, 2012): ones based on traditional modes of instruction, typically hosted by proprietary learning platforms (like our virology example), and ones based on connectivist peer-learning approaches, typically built on open source platforms (Siemens, 2005).

The MOOC language collections we have built demonstrate the affordances of the FLAX software. FLAX is open source and can be downloaded to build language support collections with any text-based content and supporting audio-visual material, for both online and classroom use. It is designed so that non-expert developers—whether language teachers, subject specialists, or instructional design and e-learning support teams—can build their own collections.

Content varies in terms of licensing restrictions, depending on the publishing strategies adopted by institutions for their content. FLAX has been designed to offer a flexible suite of linguistic support options for enhancing such content across both open and closed platforms.

6 INTO THE FUTURE

A recent review commissioned by the UK Department for Business Innovation and Skills (2013) tracks the progress of the MOOC phenomenon as it moves from experimentation into maturity. Current work focuses on meeting the accreditation needs of learners, and on devising and developing new pedagogical models to better support online learning.

FLAX's capabilities for building language collections with comprehensive facilities for search and retrieval, and customized interactive learning of key domain terms and concepts, addresses the needs of both native and non-native speakers who are interested in engaging deeply with specific academic resources in English while developing their receptive reading and listening skills.

We plan to investigate further MOOC collections to determine whether FLAX can assist not only with mastery approaches to learning and assessment like those employed in the *Virology* course, but also with constructivist approaches that support peer learning and assessment—where collections will be derived from student texts, seminar discussions, and peer-review texts, as well as from expert text and lecture transcripts. This will promote the aggregation of crowd-sourced content for collaborative peer learning.

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A Curriculum for Future Information Technology

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Keywords: Computer Science, Information Systems, UIT, Information Technology, Career Tracks, Topics.

Abstract: Computer science, information systems, information technology and other related programs have been evolving over the years to prepare students for the ever changing work force or to become research scientists. These program structures and curriculum gets updated rapidly even before a student had a chance to complete a four year cycle. When a student graduates, there may be a daunting challenge to find a right fit for a right job in today's global market. This paper proposes a curriculum paradigm that is based on sound engineering principles and need for applied education. The curriculum proposed here is based on student needs and industry outlook. It reduces educational cost for students, administrative cost for teaching institutions and training cost for industry. It also provides a first cut of curriculum that integrates a variety of disciplines under the information technology umbrella. The curriculum taxonomies are shown to illustrate the proposed concept. An initial road map and time schedules are shown to demonstrate the feasibility of this concept. The roles of students, faculty and industry supervisors are discussed. The approach proposed here will have a broader positive impact in information technology when adopted. Further research is needed to fully exploit the proposed concept.

1 MOTIVATION

Current education and curriculum in the global world is changing rapidly in many dimensions. There is a big debate on online versus on-campus education and there is no clear consensus on this issue. The cost of education for students and their parents is becoming increasingly unaffordable. The competition from the world markets is forcing students to quickly adapt to new technology, tools and emerging applications. Countries like India and China are producing information technology (IT) professionals in masses and in fast pace to quickly get them into job market. Some of these professionals may not have traditional IT degree, but they do perform well at work and cope with the changing environment. The international workforce is quickly replacing the domestic elites in current IT industry.

There is tremendous commonality and repetition in many of the fields such as computer science, information systems, information technology and related areas in most countries. All these disciplines can be simply classified under a large umbrella referred to as a unified information technology (UIT).

Current curriculum in UIT is based on a "silos" approach. It is categorized on subjects and the ability of students to learn in a chronological order. The international UIT work force today demonstrates that rigorous training in a given area also provides sufficient background in performing most of today's UIT jobs. Other disciplines provide some insight into new curriculum ideas, which are worth considering. In medical field, the four year curriculum is divided into two parts, where students study for two years in the classroom and work for two years on rotations (hands-on) to select a specific field. Similarly, in some engineering disciplines, the curriculum uses a common curriculum for two years and 2-3 years to specialize in a given field. These models provide motivation to develop a curriculum for UIT education.

2 INTRODUCTION

The UIT discipline referenced in this paper is presumed to be an umbrella for many computer related fields as mentioned before. A typical "**silos**" map for curriculum for computer science (CS), information systems (IS) and information technology (IT) is shown in Figure 1. Each column in the figure is a "silo" based on its categorization and ability of a student to learn in a chronological manner. However, there are some inter-dependencies in these "silos" as some topics are common among them. For example, some programming concepts learned in CS1 and CS2 are used in an OS class. This approach requires a four year period to complete a given specialization. However, this structure does not train students the way industry expects, as a consequence many organizations hire highly trained person versus highly educated person.

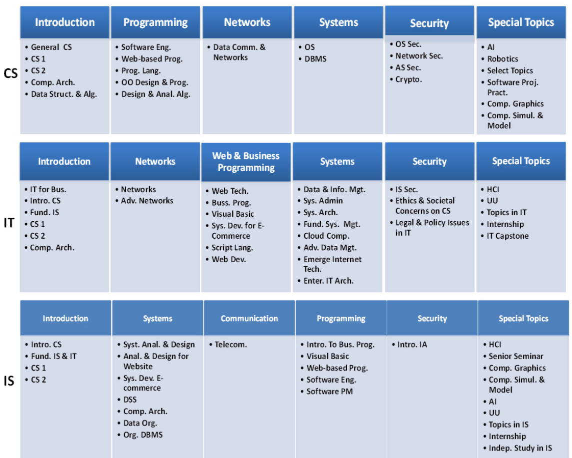

Figure 1: "Silos" map for CS, IS, IT.

This curriculum paradigm has many dimensions that address the fast changing technology and global market trends. However, it does not focus on future needs and anticipated technology. A curriculum should prepare students in the shortest amount of time with required educational background, certifications and skills that can be retained for a long period of time. It should provide a clear path to pursue careers in a particular area of expertise. It should focus on major domain applications instead of ever changing computer environments. These requirements for curriculum development need an approach than making cosmetic, pedagogical and incremental changes to existing programs. Engineering and Medicine fields have some unique characteristics that can be borrowed to develop new curriculum that will address many issues faced in current IT educational system.

3 CURRICULUM FOR UIT

The novel curriculum proposed would utilize the commonalities among many areas in IT; require practical skills for students, emerging industry needs, cost-cutting for student education and optimizing academic institution's resources. Each of these objectives will be met by the proposed curriculum. The main attributes of this proposed curriculum is described in the following sections.

3.1 Duration

Due to rapid changes in technological and industrial needs, the 4 year college should be reduced to 3 years. This will reduce the education cost and help students and parents in many ways. The three year period proposed is a continuous period including summers. This includes six semesters and three summers. It does not imply that four years without summers is close to three years with summers. Some of the time is used for internships, practical learning and certifications.

3.2 Topics

The current course structure will be divided into topics, which can be mixed and matched to suit a particular career track. For example, a database course is divided into many topics such as relational data model, data modeling, transactions, concurrency control, database programming and database administration. There is no course concept in this new model. In addition, certifications (research experience), applied experience and theoretical topics (foundations) are added to the curriculum to prepare students for industry and research careers. These items are modeled as a four layer architecture model as shown in Figure 2.

3.3 Teachers

The teaching approach that will be adapted in this curriculum would use different teachers drawn from academia, research labs and industry. It would consist of academicians, industry supervisors or domain experts and researchers. Each of them will play their own role in the curriculum. A single teacher teaches his/her expert topic instead of an entire course. As the topics change rapidly, domain experts from industry are brought in to cover emerging topics as needed. An academician at an institution may teach theoretical topics that he/she is considered as an expert or knowledgeable in the subject. An industry supervisor/domain expert will cover applied experience and certifications that are needed in the program. Similarly, a researcher from a research lab or another academic institution will provide research experience components relevant to the learned theoretical topics by students. The medium of teaching can be in the class-room, on-line, industrial site, or a lab depending on the type of topic and experience. All of the above faculty categories must be compensated by the host academic institution and be evaluated by students.

3.4 Career Tracks

In this model, the curriculum prepares a student for a given career track based on his/her interests and performance. Industry needs and their required skills and expertise will play a major role in the curriculum process. The career tracks depend on current industrial needs, which may change often. Advisors will assist students to choose an appropriate track that is suitable to their primary interest. There can be many types of career tracks in UIT. These tracks may depend on a specific area or a combination of one or more areas. A network security engineer track may require multiple topics and experiences along with some sort of certifications. The four layer model shown in Figure 2 illustrates this curriculum hierarchy.

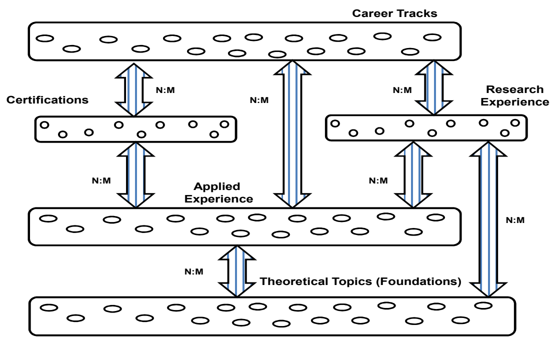

Figure 2: New Curriculum Architecture.

Students may need to take many topics and have many applied experiences to get into a particular career track. Some career tracks may require research experience and applied experience to complete a particular career. The proposed four layer model follows a many to many mapping from one layer to the next. This is a more general view of the model, however some layers may only have many to one mapping between them. That is, there are cases where many theoretical topics map to one applied experience. For example, one needs to learn data structures, TCP/IP and process management to write a Web server application. This is a many to one mapping. In another example, Web server and Process Management applications require knowledge of process or thread creation. This is a many to one mapping. Overall, many-to-many mapping cover all cases in this layered approach.

The disadvantage of training students for single track is that they may not find a suitable position in that track after graduation. In this case, a student can always switch to another career track and pursue that track to find a job. This is similar to medical schools, where they do a second residency. Students must choose the right career track to start with so that there will be no need for later switch. Advisors must point students to the right track based on market conditions. This approach is different from a current paradigm, where a student obtains a generic degree, sometimes special tracks (such as security, Web, E-commerce, networking) and could apply for many available jobs. As the industry is very much focused on hiring students with a specialized skill, the proposed solution should work better. One can do two career tracks, which may require more time to complete the program. The career track switch can also be done after working for a while, by upgrading your skills.

4 IMPLEMENTATION

The proposed curriculum has many facets in its implementation. The nature of this approach brings many unconventional avenues and innovations. The following sections provide detailed descriptions for implementing this model.

4.1 Homogenize IT Areas

As shown in Figure 1, UIT areas share many topics in common. Consider a data communication network course in each area. The fundamentals in data communication networks are the same for all areas, however their scope of leaning is different. For example, CS students learn to implement protocols, IS students focus on operation of protocols, and IT students train for network administration and configurations. All of them need foundations for data communication networks. Similarly, some other common areas such as Web Applications, Web Security and Software Engineering can be homogenized. There may be some areas that are very unique in a particular field, where there is no need to homogenize the area.

4.2 Development of Theoretical Topics

Developing unique topics in UIT requires more research and understanding of the proposed curriculum. To demonstrate the feasibility of the proposed concept, some database and network topics as well as required topics are identified and used for illustration. This is by no means a comprehensive study for the identified areas. The process of identifying a topic should be similar to identifying entities in a database model. A topic should have some theoretical or empirical grounds and unique in its domain. A topic can also be viewed as a nugget that has some foundation for future extension. For example, relational data model is a topic which has sound theoretical basis. Similarly, inter-process communication is a topic, which proliferates throughout Web technology. These topics are very unique and they have broader impact in their domain applications. We need to identify all such topics in UIT so that we can build a solid foundation for achieving the proposed curriculum. The ACM and IEEE Computer Society curriculums (ACM, 1968); (Computer Science Curricula, 2013); (Computing Curricula, 2013) over the years have used a different type of approach which is based on courses and fields that have emerged over the years and has no stability in its mission. The proposed curriculum divides existing curriculum into topics (more granularity) thus making them more stable. That is, there is a need for engineering and science principles in UIT education instead of training students for immediate needs of industry and technology evolution and making them obsolete after few years.

4.3 Development of Applied Experience

Applied experience involves hands-on training for UIT students. After learning theoretical topics, they need to get hands-on experience with current tools and techniques in industry. Academic institutions may or may not have resources such as Database tools at their home institution. Students also need experience in developing real world systems which can be provided by industry and through their experts. A typical applied topic may involve configuring a large network for operation and maintenance or a programming experience where students work with a large software project and building a module. We need to identify applied experience projects that are related to theoretical topics, which require further research in this area.

4.4 Development of Research Experience

Research experience involves understanding current research areas and problems. After learning theoretical topics and may be some applied experience, students can be exposed to some research experience. This experience can be provided to students through collaborations and internships with research organizations and other research institutions. We need to identify some topic areas to develop such research experience projects. A typical topic may consist of applying multi-core architecture knowledge to partition a computer intensive application to achieve higher performance. Such projects should be undertaken by students who are interested in research careers.

4.5 Identify Certifications

In today’s industrial careers, certifications are vital components. Certifications such as A+, Network+, CCNA, CCNA, CISSP, and Security+ (Hein, 2012) are required for some jobs. These certifications cover wide array of topics and sometimes span across many areas. The theoretical topics and applied experience provided to students should cover some areas of certifications. A student pursuing a particular career track which requires certain certification should get complete knowledge and experience to pass that certification. There should not be a need for the student to get outside help to pass a certification. Identifying needs for certification requires further research to develop a comprehensive curriculum.

4.6 Development of Career Tracks

Today’s career tracks are driven by current trends in technology. The current trends in technology are driven by industry without any scientific basis; otherwise they would have been stable for a long period of time. Sound principles must be extracted from the emerging technology and incorporated into topics in the curriculum. This requires more research and understanding of the proposed curriculum to cope with the current trend in career tracks. To illustrate the proposed concept, we have identified some career tracks in database and networks from Web sources (Career Tracks, 2013) and shown them in Figure 3.

4.7 Mapping Topics to Career Tracks

Mapping theoretical topics to career tracks follow the four layer architecture presented in Figure 2. This process requires further research to layout the exact mappings. In order to show some sample mappings, we have studied database and network areas and developed some mappings as shown in Figures 4 and 5. We need to get industry, research and academic organizations to develop all possible mappings from topics to career tracks.

4.8 Identify Industrial Supervisors

The proposed curriculum requires a strong collaboration between industry and teaching institutions. When topics are clearly identified in UIT, experts from industry need to be identified who can provide applied experience for students. Students may get this experience in their labs at their home institution or they may get this at a chosen industrial site. The supervisors who train students should be compensated by the host institution.

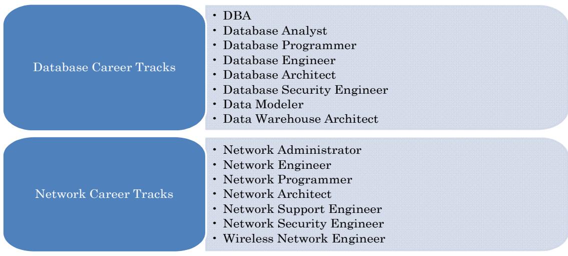

Figure 3: Career Tracks.

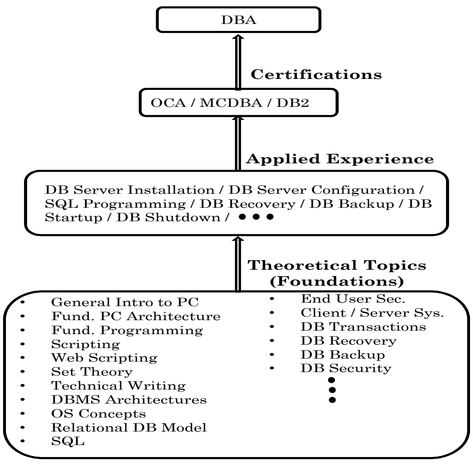

Figure 4: Database Topics / Career Tracks Mappings.

4.9 Identify Researchers

The proposed curriculum also requires a strong collaboration between research institutions and laboratories. Some students may pursue research careers after graduation and they need to be exposed to research trends to appreciate the type of environment and problems to be addressed in an area. The researchers who provide training to students should be compensated by the host institution.

4.10 Medium of Teaching

Media of teaching has many dimensions in this model. Theoretical topics can be taught in classroom or online. Applied experience can be obtained in a laboratory at host institution or at an industrial site working with a supervisor. Research experience can be obtained at a host institution, research organization or a research laboratory. Knowledge and practical experience for professional Certifications can be gained at a host institution or online provided by an expert professional in a given area. The teaching environment and medium is different from a traditional setting as done today.

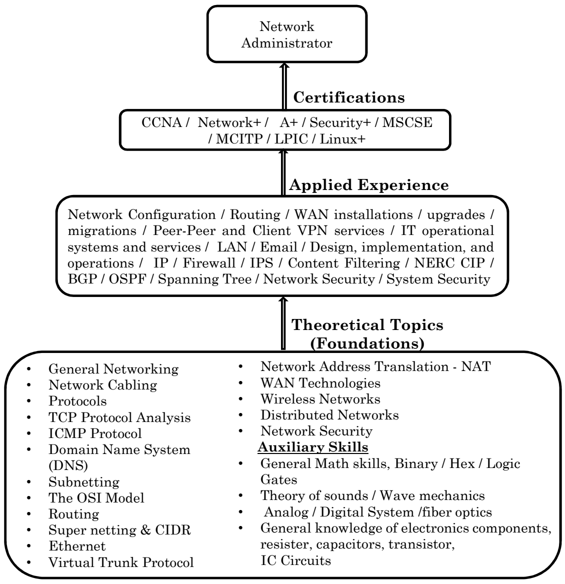

Figure 5: Network Topics / Career Tracks Mappings.

4.11 Development of Grading Policy

The grading policy needs more research and evaluation. However, the following grading policy is suggested for the proposed curriculum. For a given career track, a cumulative grade is given for each semester including summers. Over a three year period there are a total of 9 semesters including summers. A final cumulative grade is given for the entire program based on the average of 9 semester grades. For each topic, applied experience, research experience, and certification there will be an independent grade in each semester. After a particular topic, experience or certification is complete a letter grade will be given by an instructor or a supervisor. All these grades are used in each semester to compute a cumulative grade point for a particular semester. A letter grade of A, A-, B, B+, B- and C are used in the curriculum. Any cumulative grade less than C in any semester will be a fail grade and that student will have to repeat the whole semester. More studies are needed to refine this grading system.

4.12 Student Academic Plan

Figure 6 shows a typical academic plan for a particular career track for the 3 year period. In the plan, students are required to spend the first four semesters taking theoretical topics. These topics are intended to provide some foundation in the field of UIT and also prepare them for the applied experience topics. They will then spend the next 3 semesters doing rotational applied experience areas, where they will be assigned to industry and get training under a supervisor. One semester will be optional for those who want to have a research experience to conduct research under a researcher. If a student decides against the research experience then they have to continue with the applied experience. Students also have one semester option to prepare and take certifications in their chosen career tracks. Similarly student can opt against taking the certification and can continue with the applied experience. More studies are however needed to refine this academic plan.

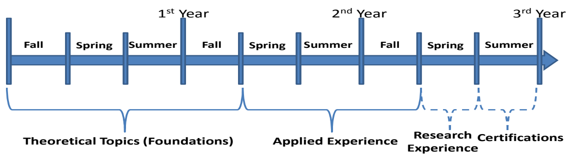

Figure 6: Academic Plan of proposed Curriculum.

4.13 Development of Tuition Plans

Tuition and fees is an institutional issue. We don't have any particular suggestions for this issue. However, a simplest way to charge tuition is based on a semester.

4.14 Payment Plans for Teachers

As the curriculum is divided into topics, applied experience, research experience and certifications, one can setup a payment plan based on the same categories and number of students. This issue is also related to an institution and we don't have any particular plan for this item.

5 PROS AND CONS

The proposed curriculum is novel and is not evolutionary in nature as such it will face resistance in its implementation. It needs a strong collaboration between academia and industry. However this collaboration will be hard to achieve as industry is not in the business of educating students. The UIT curriculum offers many benefits in spite of the above drawbacks. Students get full education and training from a bottom up approach along with hands-on experience and needed certificates. When a student graduates, he/she is ready for a real world job. Industry benefits immensely as they can hire students who don't need much training. The academic institutions can reduce their permanent faculty and overhead as supervisors and researchers take some of the teaching load in applied experience, research experience and certifications. Students will get better jobs in industry, possibly with the companies they were already associated with during their education. Fundamentals or theoretical knowledge acquired by students will remain with students for long. The UIT requires further research and pilot sites to understand and study the implementation issues.

6 CONCLUSIONS

This paper proposed a UIT curriculum that has a broader impact in education. The UIT curriculum approach is described in detail. A four layer architecture model is presented to capture its concept. Some sample examples of career tracks are illustrated to describe the new curriculum. A timeline required to complete a career track will be three years. The implementation issues and pros and cons of this concept are outlined. The curriculum proposed here requires further research and demonstration through some pilot sites to demonstrate its feasibility.

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A Web-based Recommendation System for Engineering Education e-Learning Systems

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Keywords: E-Learning, Recommendation System, Agile Process, Teachers, Professors, Web 2.0, Software Engineering, Open Source.

Abstract: Today there is a flood of e-learning and e-learning related solutions for engineering education. It is at least a time consuming task for a teacher to find an e-learning system, which matches their requirements. To assist teachers with this information overload, a web-based recommendation system for related e-learning solutions is under development to support teachers in the field of engineering education to find a matching e-learning system within minutes. Because the e-learning market is subject of very fast changes, an agile engineering process is used to ensure the capability to react on these changes. To solve the challenges of this project, an own user-flow visual programming language and an algorithm are under development. A special software stack is chosen to accelerate the development. Instead of classical back-office software to administer and maintain the project, a web-based approach is used – even for a complex editor. The determining of the necessary catalog of related solutions within "real-time" is based on big data technologies, data mining methods and statistically text analysis.

1 INTRODUCTION

To help teachers with their different challenges about finding an e-learning solution, a web-based recommendation system for e-learning systems is under development. This recommendation web-based service enables teachers to choose an engineering education e-learning system, which matches her or his requirements.

The term "e-learning" is often used in different matters. Therefore, this definition is chosen: "E-learning is an approach to teaching and learning, representing all or part of the educational model applied, that is based on the use of electronic media and devices as tools for improving access to training, communication and interaction and that facilitates the adoption of new ways of understanding and developing learning." (Sangr et al., 2012) This definition includes any computer- and web-based tool, which is related to the education context.

A variety of e-learning systems and environments (Mayer, 2003) are observable and the amount is continuous growing: From classical computer-based training (CBT), web-based training (WBT) (Schoen and Ebner, 2013), wikis and blogs (Schoen and Ebner, 2013), podcasts (Cebeci and Tekdal, 2006) respectively educasts (Schoen and Ebner, 2013) and game-based learning (Schoen and Ebner, 2013) up to massive open online courses (MOOC) (McAuley et al., 2010; Schoen and Ebner, 2013).

To illustrate the amount of related and available resources: A simple web-search for "e-learning" ends with over one billion results, a web-search for "e-learning system" with over 480 million results! Nearly 80 unique e-learning systems can be found in short time. This fact demonstrates the problem: The interested teacher must investigate this amount of information to find an e-learning system, which matches their personal requirements. Another problem is: The teacher might not be able to choose a system, which matches their requirements, because it is not trivial to understand all the technologies and differences between the unique systems.

2 REQUIREMENTS AND CHALLENGES

The main precondition of the desired recommendation system is that the related e-learning systems are comparable. Moreover, a catalog of related solutions must exist. The approach to reach the comparable state is to find a set of necessary attributes that describes the characteristics of engineering education e-learning systems. These common e-learning characteristics must base on a broad scientific consensus: To realize this, the input of many experts is acquired.

The collected data about each e-learning system, together with the e-learning characteristics, results in a comparable data sheet about each e-learning system. This data sheet is subject of continuously changes to ensure that the data sheet is up-to-date and represents the current state of each system. Also the e-learning characteristics are subject of changes to cover all related kinds of e-learning.

The traditionally approach to determine the catalog with the solutions uses a lot of resources (time, staff and money): Pay and get every e-learning system, prepare a server environment and install all systems. Then investigate the system (as teacher and student) and fill-up the data sheet. It is possible to speed-up this by using virtualization environments (Rosenblum, 2004) like e.g. a type 1 hypervisor (Fenn et al., 2008) with templates for the required environments, system snapshots and derivation between them.

The new and promising approach to determine the catalog with the available solutions is based on text mining: Crawling and parsing the public vendor and community information about the e-learning systems and store the raw data. Next, the raw text data is able to get analyzed to find out about the textual context. A half-automated algorithm suggests then a value for each characteristic, to assist the employee. Such a process is able to get executed e.g. every quarter to ensure that the data sheets are up-to-date.

To provide a convenient tool to develop and maintain the questionnaire, a new visual user-flow programming language is defined. This language is linking the catalog of solutions, the questions with further explanations for the teachers, the e-learning characteristics and the model of the user-flow together. Compared to existing survey solutions, the visual model and the deep integration are new.

Another challenge is that teachers expect a current, modern, responsive (Mohorovicic, 2013) and accessible user interface (UI). This is comprehensible, because it allows any teacher with any device and any handicap to use this web-based recommendation service. A responsive UI saves also time, because there is no need for an additional mobile and tablet websites (Mohorovicic, 2013). Some web frameworks (e.g. Bootstrap[1]) assist the developer in these fields.

For further research (e.g. about e-learning systems and the teachers requirements to these systems), it would be helpful to collect some kind of key performance indicators (KPI) from the recommendation system. The data must be anonymous to keep the teachers privacy. Not only the end results must be logged, also e.g. the reaction time per question and – if present – the cancellation point etc. It is also interesting to capture all single decisions of any anonymous teacher to enable research e.g. in psychology fields.

3 USER FLOW LANGUAGE

To enable the scientific assistants to model efficient the user-adapting questionnaire and to provide a convenient tool for maintaining the questionnaire, a new visual programming language (Hils, 1992) is defined.

The language is simple: Different squares – called "function blocks" – are connected by wires. For different purposes, different function blocks are present: Start, end, question, numeric and range blocks. Every function block has no or one input connector and no, one or three output connectors – this depends on the kind of the block. Behind every block, some data is stored: The reference to the common e-learning characteristic, a question, additional explanation text or just a text message – depends on the kind of the block.

Every program must have exact one start block, and at least one end block. The visual program must read from left to right: From the start block at the left, then follow block by block until reaches any of the end blocks. The concrete questionnaire can then deviated out of the visual program by simple traveling through the blocks. There is no special algorithm required to get or generate the questionnaire.

With this visual language, the visual program for the questionnaire has to be built. Explaining figure 1 as current example – to clarify the visual language: At the left, the start block was placed. The interviewee gets an introduction message to read. The flow is directed to "Question 1", a question block. The interviewee gets a question (the question was defined before by a research assistant) and an additional explanation text. Related to the answer, the flow reaches "Numeric query 1" or "Question 2". The "Numeric query 1" prompts the teacher to answer a numeric question like e.g. "How many students are in your

[1] http://www.getbootstrap.com

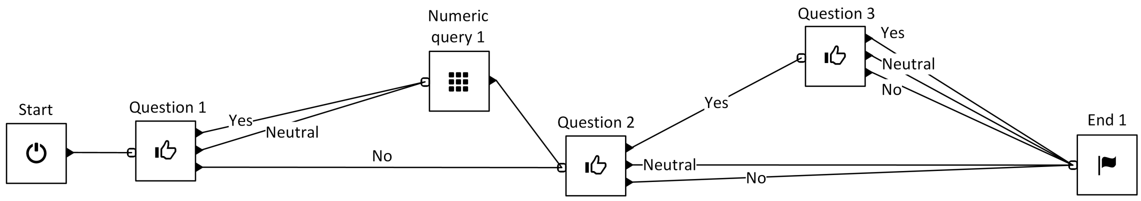

Figure 1: Example of the user flow visual programming language.

class?" From this block, the flow also reaches "Question 2". After "Question 2", the flow is able to reach "Question 3" or "End 1", related to the answer. "End 1" is also reached after answering "Question 3". At the end block, the interviewee is able to read a finished message. By pressing a button, the user submits all their answers to the algorithm.

Each question block has one input and three output connectors for the further flow: A yes-output, a no-output and a neutral-output. This corresponds to the possible answers of the interviewee. "Yes" means that the issue (subject of the question) must be present, "no" means the issue is not present or can be disabled and "neutral" means, that the issue does not matter.

A range block (this kind of block is not part of the example at figure 1) contains a text and an explanation text for the interviewee. To represent a range, this block needs two references to the corresponding parts of the common e-learning characteristics. This kind of block has one input and output connector.

While this project grows, the amount of different kind of function blocks will increased as necessary. For any new kind of block, also the algorithm (see section 5) must be extended to cover the new functionality. New types of blocks are caused by changes at the common characteristics, to cover new requirements on the e-learning market.

For convenient usage, a simple web-based editor is under development. Thereby, it is possible to maintain the questionnaire without any programming skills. The whole life-cycle of the editor and the language is also convenient: There is no installation required, updates are only a server-side deployment and any kind of maintenance just occur on the server-side.

4 ENGINEERING

4.1 Process

To be able to react on new requirements on the whole process (software engineering, determining catalog of solutions, development at the algorithm etc.), agile best practices are chosen (Wolf, 2011; Fowler and Highsmith, 2001; Poppendieck and Cusumano, 2012):

- Use cases: Define a few use cases by drawing diagrams or by writing small so called "user stories" (Wolf, 2011).
- Simplicity: Develop just necessary parts and leave anything which is not required (Poppendieck and Cusumano, 2012; Wolf, 2011).
- Fast: Release fast and as many as possible to be able to get feedback from others (Poppendieck and Cusumano, 2012; Wolf, 2011).
- Communication: Get early and continuously feedback from the customer, to ensure the project fits the requirements (Wolf, 2011).

Additionally, not manageable challenges are divided into smaller – but manageable – challenges (Kuster, 2011; Wolf, 2011). It is also necessary to choose the right tool for right purpose: Do not use the same tool for anything – there are right purposes for any tool, but not all tools are convenient for all problems.

Even though different changes at the last three months, it was possible to reach the current state after just eight weeks of work with just one person: This is perhaps related to the agile process. The process is promising for the further work and research.

4.2 Client-Side: Web-UI Approach

At least two tools are required for the back-office: The editor for the visual language and the product editor. While the product editor is quite simple, the editor for the visual language is even more complex. Anyhow, a new approach is tested: Instead of developing the website for the teacher's questionnaire and additional software for the back-office (with Java or .NET), anything will be developed as web-application.

For the web-application (for the back-office tools and also for the teacher's questionnaire) just HTML5, CSS and JavaScript with Bootstrap[2] and jQuery[3] is used. Thereby, it is also useable on tablets like e.g. iPads – independently of the operating system. Further, also the final client performance is fine.

[2]http://www.getbootstrap.com

[3]http://www.jquery.com

4.3 Server-Side: Software Stack

On the server-side, a wide range of options are available. The best fit is a ”BGMR stack”: FreeBSD[4], nginx[5], MongoDB[6] and Ruby[7]. FreeBSD (Niessen, 2012) is very robust, secure, uses small resources and with the concept of ”Jails” (Kamp and Watson, 2000; Kamp and Watson, 2004) a powerful virtualization (Rosenblum, 2004) environment is provided.

The web-server nginx (Nedelcu, 2013) is famous as powerful proxy, load-balancer and fasted server for static content (Dabkiewicz, 2012). Nginx delivers all necessary static data for this project (images, CSS, JavaScript, fonts etc.) But nginx is the wrong tool to deliver dynamic content, because the handling of external processes like e.g. the common PHP[8] is less efficient (Dabkiewicz, 2012). Therefore, non-static requests are passed-through to an application server.

MongoDB (Chodorow, 2013) is a robust, fast (Boicea et al., 2012; Wei-ping et al., 2011) and scalable database. For the most Web 2.0 projects, MongoDB fits perfect, because the database is document-based and uses JSON (Crockford, 2006). If the project grows, the database is also able to scale.

Ruby is an object-oriented programming language (Flanagan and Matsumoto, 2008) that provides a very convenient and fast way to develop web applications: On top of Ruby, the Sinatra[9] framework (Harris and Haase, 2012) provides an own web-centric DSL (domain-specific language). This enables a strong focus to web-oriented programming and reduced the necessary overhead a lot. While the project runs on the development environment with Ruby, for the production environment it is designated to run it with JRuby (Nutter, 2011) on JavaEE with the JBoss application server (Kutner, 2012).

This approach is very promising, because it speeds up the development, keeps the code clear – which makes the maintenance easier – and provides later with JRuby the power and scalability of JavaEE and the JBoss application server (Nutter, 2011; Kutner, 2012).

5 ALGORITHM

To get the expected results out of the teacher’s answers, an algorithm is under active development (see figures 2, 3, 4 and 5). The current state of the algorithm is constructed and validated with dedicated test data: As developing and testing environment, a normal spreadsheet application is chosen. A table with test data is representing the results of the questionnaire (the teacher’s answers).

The term ”issue” means in the context of the algorithm an element of the common e-learning char-

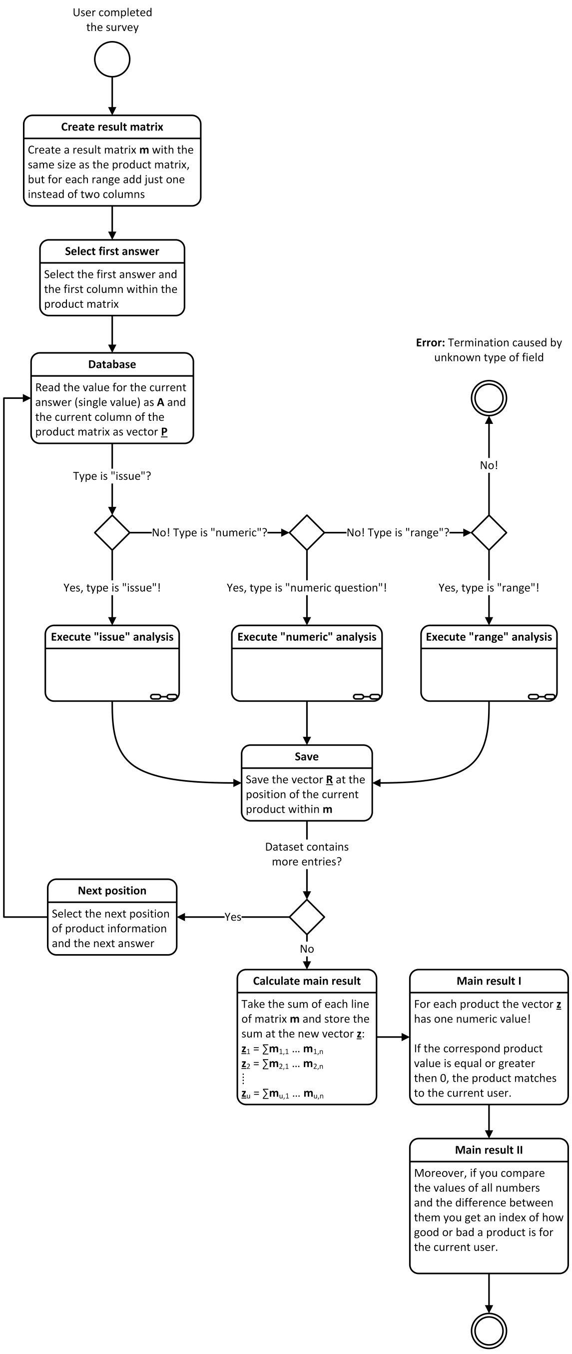

Figure 2: The recommendation algorithm to suggest e-learning systems.

[4] http://www.freebsd.org
[5] http://www.nginx.org
[6] http://www.mongodb.org
[7] https://www.ruby-lang.org
[8] http://www.php.net
[9] http://www.sinatrarb.com

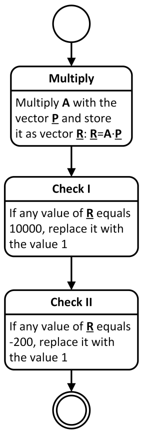

Figure 3: The sub-algorithm for the ”issue” analysis.

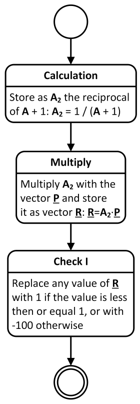

Figure 4: The sub-algorithm for the ”numeric question” analysis.

acteristics, e.g. a product function, product behavior or a didactic method, but not a numeric or range question (see section 3 for the differences). As input, the algorithm expects the static catalog of solutions as matrix: Horizontally the columns with the product issues, numeric questions and ranges etc. and vertically the rows with the products. The possible types of columns are corresponding to the available types of function blocks (see section 3).

Out of the product point of view for the product data: Each issue can obtain the value -100 (the issue is not present), 1 (the issue is present and cannot be disabled) or 2 (the issue is present and can be disabled).

A range, e.g. the possible amount of students (from/to), is provided as two columns inside the matrix. Moreover, numeric fields are possible for e.g. the price, which are provided as one column inside the matrix. At the moment, numeric fields are able to hold only positive numbers (include 0).

Another input for the algorithm is the teacher's answers, provided as vector. Out of the teacher's point of view: Each issue can obtain the value -100 (issue is not present or can be disabled), 0 (issue does not matter) or 1 (issue must be present).

For each range, the answer can be a positive number (include 0) to represent e.g. the amount of students – or -100 if this does not matter. Finally for each numeric field, the answer can be a positive number (include 0) to represent e.g. the teacher's budget – or -100 if this does not matter.

The start point (see figure 2) is the end of the teacher's questionnaire. As first step, the result matrix $\mathbf{m}$ is created, with the same amount of rows as the product data and the nearly the same amount of columns (but for each range only one instead of two columns).

Important to know: The first question from the questionnaire corresponds to the first answer and this corresponds to the first column within the product matrix and also to the first column within $\mathbf{m}$! Furthermore, a teacher receives might not all questions: The questionnaire is dynamic and user-adapting – the teacher gets only necessary questions. Any skipped question results implicit in the answer -100 which means ”does not matter”.

The next steps are repeated for each pair of an answer (the answer as a single value, here called $\mathbf{A}$) and corresponding column out of the product matrix as vector $\underline{\mathbf{P}}$.

The algorithm is now branching out by the column type (for now: issue, numeric or range). If an unknown type of column is found, the algorithm gets unexpected terminated. The sub-algorithms for the different types are found at figure 3 (type is ”issue”), figure 4 (type is ”numeric question”) and figure 5 (type is ”range”).

- In case of ”issue”, multiply $\mathbf{A}$ with $\underline{\mathbf{P}}$ and store the result as vector $\underline{\mathbf{R}}$: $\underline{\mathbf{R}} = \mathbf{A} \cdot \underline{\mathbf{P}}$. Check then, if any value of $\underline{\mathbf{R}}$ equals 10000. If so, replace it by 1. If any value of $\underline{\mathbf{R}}$ equals -200, replace it also with 1.
- If the type of the current column is ”numeric question”, store as $\mathbf{A}_2$ the reciprocal of $\mathbf{A}+1$: $\mathbf{A}_2 = \frac{1}{\mathbf{A}+1}$. Now multiply $\mathbf{A}_2$ with $\underline{\mathbf{P}}$ and store the result as vector $\underline{\mathbf{R}}$: $\underline{\mathbf{R}} = \mathbf{A}_2 \cdot \underline{\mathbf{P}}$. Replace all values of $\underline{\mathbf{R}}$ with 1 if the value is less or equals 1 or otherwise replace it with -100.
- The ”range” type is represented by two columns so instead of one $\underline{\mathbf{P}}$ this type has two vectors $\underline{\mathbf{P}}_{\text{min}}$ and $\underline{\mathbf{P}}_{\text{max}}$. If $\mathbf{A}$ equals -100, create the zero vector $\underline{\mathbf{R}}$ with the size of $\underline{\mathbf{P}}_{\text{min}}$ and this sub-algorithm is done. Otherwise, store as $\mathbf{A}_2$ the reciprocal of $\mathbf{A}+1$: $\mathbf{A}_2 = \frac{1}{\mathbf{A}+1}$. Next, multiply $\mathbf{A}_2$ with $\underline{\mathbf{P}}_{\text{min}}$, $\underline{\mathbf{P}}_{\text{max}}$ and store the result as $\underline{\mathbf{R}}_{\text{min}}$ and $\underline{\mathbf{R}}_{\text{max}}$. Replace now any element of $\underline{\mathbf{R}}_{\text{min}}$ with 1 if the value is

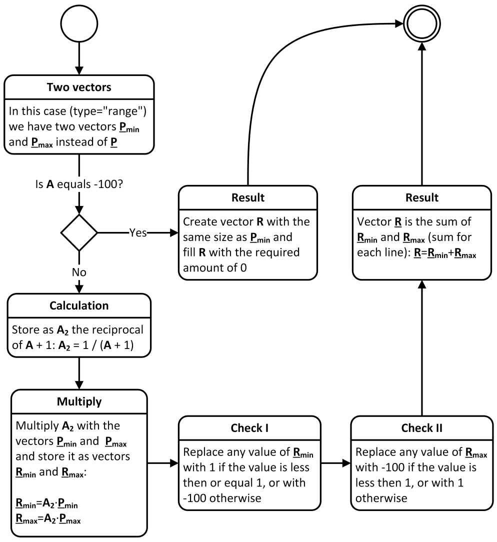

Figure 5: The sub-algorithm for the ”range” analysis.

less or equals 1, otherwise replace it with -100. Also replace any element of $\underline{\mathbf{R}}_{\text{max}}$ with -100 if the value is less than 1, otherwise replace it with 1. The result vector $\underline{\mathbf{R}}$ is now $\underline{\mathbf{R}} = \underline{\mathbf{R}}_{\text{min}} + \underline{\mathbf{R}}_{\text{max}}$.

After the right sub-algorithm, the result vector $\underline{\mathbf{R}}$ must be stored at the corresponding position in $\mathbf{m}$. If not yet all pairs of answers and product data are executed, then select the next pair and repeat the steps above. If no pairs are left, take the sum of each line of matrix $\mathbf{m}$ and store the sum at the new vector $\underline{\mathbf{z}}$:

$$
\begin{aligned}
\mathbf{z}_1 &= \sum_{n=1}^{v} \mathbf{m}_{1,n} \qquad (1)\\
\mathbf{z}_2 &= \sum_{n=1}^{v} \mathbf{m}_{2,n}\\
&\vdots\\
\mathbf{z}_u &= \sum_{n=1}^{v} \mathbf{m}_{u,n}
\end{aligned}
$$

$$
\underline{\mathbf{z}} = \begin{pmatrix} \mathbf{z}_1 \\ \mathbf{z}_2 \\ \vdots \\ \mathbf{z}_u \end{pmatrix} \qquad (2)
$$

The variable v starts at 1 and grows up to the amount of issues, numeric questions and two times the amount of range questions. The variable u starts at 1 and grows up to the amount of products.

Interpretation of the results: The vector $\underline{\mathbf{z}}$ provides for each product one value. If a value is greater or equals 0, the corresponding product matches to the teacher's requirements. Moreover, if the resulting values are descending sorted, this new ordered list represents the teacher's best matching solution down to the worst solution[10].

6 RESULTS

The chosen software stack has already proved its power: The development time has been short and the source code is clear, with less overhead and a strong focus to web development. Thereby, the first prototype is a responsive web solution: This saves time, because the mobile devices are covered without an additional mobile app. The agile process made it possible to react on changes to the subject of e-learning and also to common project changes.

The first technical prototype with the visual programming language and the questionnaire is running without errors: It is possible to write a visual program and test the user flow through the resulting questionnaire. It is possible to change the visual program while users are inside the user flow of the questionnaire: The users in front of the changed function blocks are receiving directly these changes, and users behind the changed blocks are not affected at all. This feature enables to run a long-term system with no or less maintenance impacts.

The visual web-based editor for creating a visual program is convenient and enables also staff without computer science knowledge to create a visual program. The first version of the algorithm is passing all test cases with dedicated test data: The algorithm is working deterministic and the results are correct for any expected input. In case of the comparable characteristics for the related e-learning solutions, which are the precondition for this recommendation system, a first proof of concept exists.

7 CONCLUSION AND OUTLOOK

To meet the precondition of comparable characteristics for related e-learning solutions it is promising to get the input of experts to reach a broad scientific consensus. Because it was possible to build a proof of concept for the characteristics, it is confident to meet this precondition. The recommendation algorithm needs further research to investigate the performance under real conditions with a huge solutions catalog and also huge amount of answers. Therefore,

[10] If the value is less than 0, the product is of course not a ”solution” for this teacher.

the algorithm must be implemented into the prototype.

The new visual user-flow language enables to build user-adapting questionnaires. This saves processing time for the teachers, because their get just the necessary parts of the whole questionnaire. Nevertheless: The user-flow program is able to cover the complexity from unexperienced to advanced teachers, regarding to the e-learning subject.

In the long-term view: If the web-based recommendation system goes online, the service enables teachers to save time and let them focus to the engineering education. Later, the recommendation system can be expanded to other disciplines, beyond engineering education. After the project reaches a more mature stage, it will be accessible as open source under the 2-clause BSD license to enable others to use and modify it.

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Sensor Monitoring in an Industrial Network
Experimental Tests for Computer Supported Education

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Keywords: Sensor Monitoring, Industrial Network, Computer Supported Education.

Abstract: The integration of field level and higher communication is expanding and ensuring ideal conditions for open networks in process automation at industry. For a better knowledge on the referred networks, some experiments were developed to ensure a better comprehension on how they work and application possibilities. The experimental tests with industrial network using a PLC (Programmable Logic Controller) based computer education, allows the electrical engineering students perform experiments on-line by a remote laboratory for the study of industrial automation process.

1 INTRODUCTION

Nowadays with the development of information technology, communication between devices and the use of standardized mechanisms, open and transparent have become key concepts in automation technology, especially in today's industrial environment. The integration of field level and higher communication is expanding and ensuring ideal conditions for open networks in process automation at industry, as it happens with the combination of AS-Interface and PROFIBUS (PROFIBUS Association, 2006).

For a better knowledge on the referred networks, some experiments were developed to ensure a better comprehension on how they work and application possibilities. For the experiments, were analyzed the behavior of sensor networks with AS-I, the devices were linked by the PROFIBUS network and controlled by the PLC S7-300 from Siemens. The whole system was configured by the STEP7 software from Siemens as well. A teaching supervisory platform was implemented in the software LabVIEW, and it provided students an online system monitoring.

2 INDUSTRIAL NETWORKS

In Figure 1 is presented the system in study, illustrating the devices and networks linking them. For a better comprehension of the networks, their operation is explained in this section.

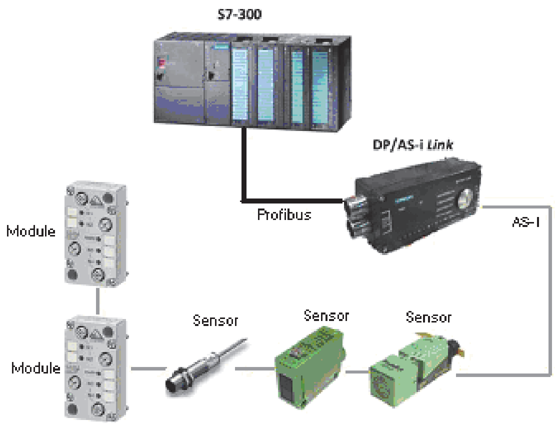

Figure 1: Simple diagram scheme of the system in study.

2.1 Profibus

PROFIBUS, an acronym for Process Field Bus, is an open industrial communication network, used mainly to make the connection of digital controllers with sensors/actuators (the field level to cell level) for both high-speed data transmission and special communication services. By being an open pattern, its independence of the manufacturer and of specification is guaranteed by norms EN50170 and EN50254. Therefore, devices from different manufacturers can communicate without any adjustment in their respective interfaces. Figure 2 presents a diagram with the PROFIBUS application areas, emphasizing the communication profile, the application used and the standard cycle time for each level.

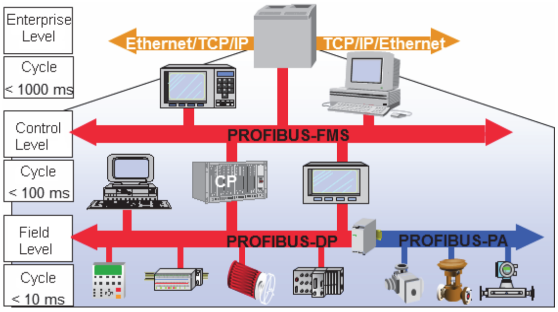

Figure 2: Diagram showing application areas of PROFIBUS.

The PROFIBUS-DP (Decentralized Periphery) is an optimized variation with high-speed connection and low cost. Suitable for the factory floor, where there is a large volume of information and the necessity of high speed communication to events is quickly treated (PROFIBUS Association, 2006). It uses a transmission technology RS-485 or optic fiber, making transmissions at rates from 9.6 kbit/s to 12 Mbit/s.

2.2 AS-I

AS-I, an acronym for Actuator Sensor Interface, is a standardized network system (EN 50295) for industrial communication and open to the lowest level of automation and came to meet certain requirements defined from the experience of members founders and to supply the market which hierarchical level is the bit-oriented (Siemens, 2010). The AS-I was designed to complement the others systems and make it easier and faster connections between sensors and actuators with their respective controllers (Siemens, 2008).

The AS-I is a master-slave type network with cyclic data capture. It has a master device, capable of controlling the entire network, reading by cycle all other integrated devices to it, called slaves. The AS-I master performs various tasks such as network boot, identification and diagnosis of the slaves and transferred data analysis (Lian, 2003). Also, usually communicates with a controller (PLC or PC) to receive control configuration of AS-I, report errors, to address new slaves, among other tasks (Becker, 2002).

Slaves are passive devices, so they may have access to the network when the master makes a request and data transfer from slave to slave is only possible through the master. Slaves can be connected to four sensors or actuators, which have their values read/written cyclically by the master. There are intelligent sensors that have an AS-I chip integrated, allowing direct coupling to the cable. There are also slaves who work with analog values, but these need four cycles of the network so that a read/write is complete (Siemens, 2008).

For proper exchange of information between the master and slave, the slaves receive a unique address that will identify them (Lian, 2003).

2.3 DP/AS-I Link

The DP/AS-I Link creates an interface between AS-I and PROFIBUS-DP networks. It operates as a common DP slave and as the master of AS-I network. Like others DP slaves, requires a DP master. It has its principle of operation similar to any other gateway device, where the protocols of the systems in question are converted (Siemens, 2000). The DP/AS-I Link is used to perform the exchange of the sensors and actuators of AS-I network to the PROFIBUS-DP network (Siemens, 1995). At the system analyzed on the experiment, it is used the DP/AS-I Link from Siemens and its image is visualized in Figure 3.

Figure 3: Image of the DP/AS-I Link from Siemens.

3 EXPERIMENTAL PLATAFORM

The devices connected by the system networks are presented in this section. Their data acquisition procedure is explained as well as their functionality in the experimental platform.

3.1 PLC S7-300

The Programmable Logic Controller (PLC) S7-300 is a modular system used in centralized or distributed applications. Its modular nature allows a quick and easy expansion, with the possibility of adding 32 modules of various types, divided into I/O modules, communication modules and function modules.

A control system based on a S7-300 is basically composed by the expansion modules, power supply and CPU. The CPU is accessed by a Multi Point Interface (MPI) port, which does the whole setup and configuration. In addition, some CPUs have a second communication interface, as PROFIBUS-DP or serial point-to-point (Siemens, 1998).

3.2 Sensors and Modules

The sensors that were used in the experiment were inductive and photoelectric.

The photoelectric sensor has a transmitter circuit responsible for the emission of a light beam and an infrared receiver circuit responsible for receiving the beam. Light can be reflected or interrupted by an object, detecting it and triggering the sensor.

At the system analyzed, it is used one of VF AS-I OS1K-VF-AS-I series, from Sense, that can be seen in Figure 4.

Figure 4: Image of the photoelectric sensor VF AS-I from Sense.

The inductive proximity sensor is an electronic device that detects the approach of metal parts. The electromagnetic field generated by a high-frequency resonant coil installed on the sensing face, suffers interference when a metal part approaches, and the signal variation is compared to a standard signal, enabling the output stage.

Two inductive sensors were used, a Pentakon PS15 + UI + AS-I series from Sense, illustrated in Figure 5, and a Bero 3RG4613-3WS00 series from Siemens illustrated in Figure 6.

Two modules make part of the system, an AS-I connector module with four outputs, identified by M12 4AR 3RG9001-0AB00, and an AS-I connector module with two inputs and two outputs, identified by M12 2E/2AR 3RG9001-0AC00.

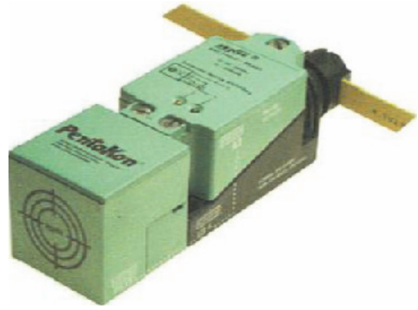

Figure 5: Image of the inductive sensor Pentakon PS15 + UI + AS-I VF AS-I from Sense.

Figure 6: Image of the inductive sensor Bero 3RG4613-3WS00 series from Siemens.

4 EXPERIMENTAL RESULTS

By the use of the growing and useful computational tools to increase the method of learning, students are experiencing a better integration with the real platforms. In the developed experiment, some procedures had been done to reach the desired results for analysis and a successful comprehension. The steps taken and the results are presented in this section.

4.1 Experiments

For a better comprehension of the devices and networks presented, experiments were made with some theory explanation and a step guide in order to monitor the sensors attached to the network and to analyze the Ladder language program configured in the PLC by the STEP 7 software, which is developed by Siemens.

Using the resources of STEP 7 software, it was possible to see how the network was configured as well as the devices, sensors and modules were configured and addressed on the network.

A network scheme with the addressed elements linked to MPI and PROFIBUS, could be seen on the NetPro as it appears in the Figure 7.

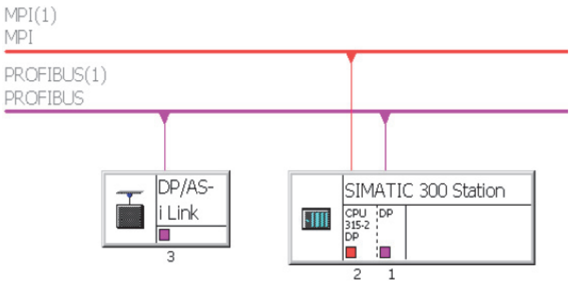

Figure 7: Representation of connections on NetPro.

On HW Config, a list of the hardware components could be seen with their configuration at the station and the respective input (I) and output (Q) address. The image of the hardware address organization can be seen in Figure 8.

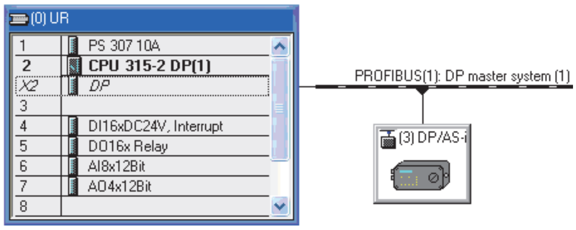

Figure 8: Representation of hardware list on HW Config.

The monitoring is used to identify the condition of the variables when the device changes of state, and these states help to understand the logic of control elaborated in the Ladder code. The configured code in the PLC is seen in LAD/STL/FBD Program blocks, where the online monitoring is also possible, and allows the user to know which inputs and outputs are activated when the sensors and modules work, as well as the blocks data.

The Ladder is a simple programming language based on blocks. The inputs and outputs of the sensors are referenced as they are configured. The code is divided in networks to simplify the understanding. This implementation eliminates the necessity of adding new electronic devices to the hardware.

After the configuration of the system in the STEP 7, a human/machine interface was implemented by the software of National Instruments: LabVIEW, so that it simulates an industrial environment via the sensors connected to a hybrid industrial network, originated from the ASI and PROFIBUS-DP's networks and using the PLC, with STEP 7 software.

OPC (OLE for process control) is a standard interface between numerous data sources and sensors on a factory floor to HMI/SCADA applications, application tools, and databases. The OPC Foundation defines the standards that allow any client to access any OPC-compatible device. The OPC Specification was based on the OLE, COM, and DCOM technologies developed by Microsoft for the Microsoft Windows operating system family. The specification defined a standard set of objects, interfaces and methods for use in process control and manufacturing automation applications to facilitate interoperability (Halvorsen, 2012).

In virtue of a network using the OPC server, the LabVIEW communicates with the PLC. In order to connect the LabVIEW with the OPC tags, it's created an I/O Server, which automatically updates the LabVIEW with the tag's values in a specific rate. It's required to create shared variables that are similar to OPC tags and obtain native access in the LabVIEW to PLC data.

LabVIEW is a platform and development environment for a visual programming language from National Instruments. The graphical language is named "G". The execution is determined by the structure of a graphical block diagram on which the programmer connects different function-nodes by drawing wires. These wires propagate variables and any node can execute as soon as all its input data become available. LabVIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel, and a connector panel (Halvorsen, 2012).

LabVIEW Remote Panels turns the application into a remote laboratory, where the created HMI with the purpose of manage and evaluate the industrial plant is fully accessible by the remote user. The interface designed with LabVIEW and used in a web browser is presented in Figure 9.

4.1.1 Pentakon Inductive Sensor Monitoring

To check the variable values in Pentakon inductive sensor, a piece of metal was passed in front of it and the LED associated with this sensor is activate and metal parts counter is incremented in the interface implemented in LabVIEW. The code in language G can be seen in Figure 10.

4.1.2 Photoelectric Sensor Monitoring

With the photoelectric sensor, any object could be used to test its operation, passing it front and ensuring no interference from others. On the HMI built in LabVIEW, the LED associated with this sensor is activated and total parts counter is incre-

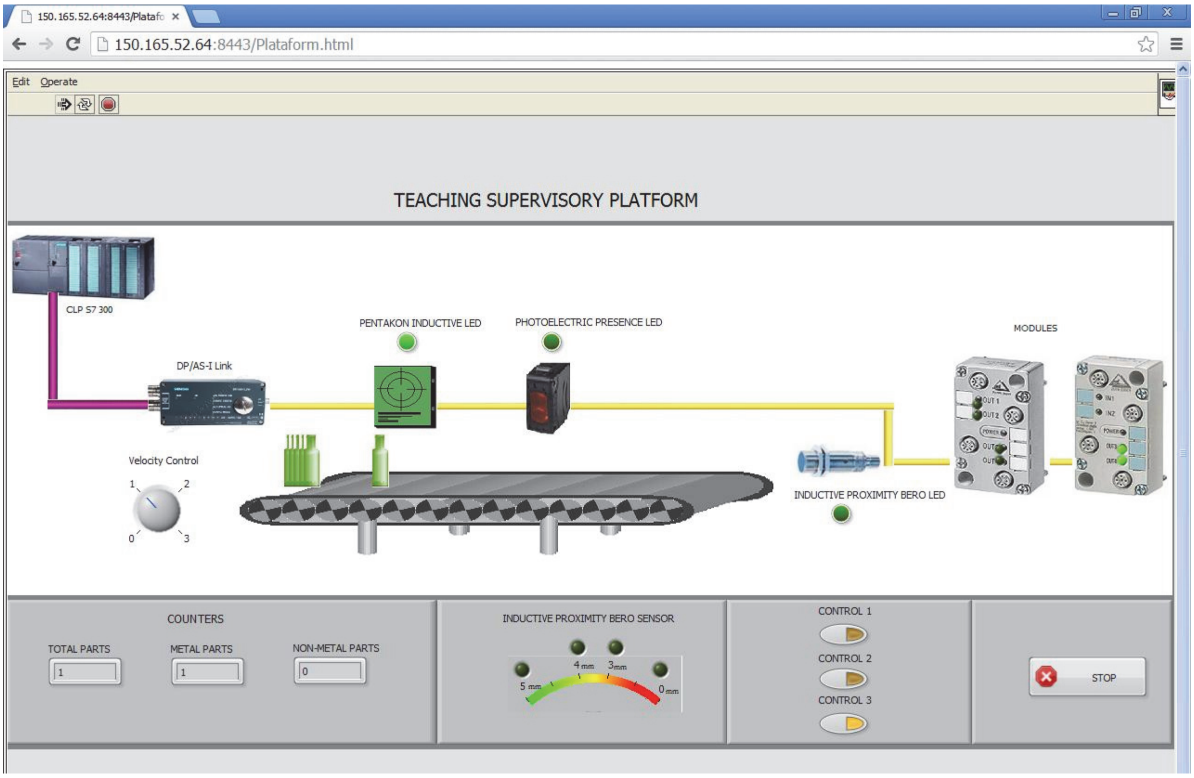

Figure 9: Online monitoring interface.

mented. Figure 11 illustrates it as implemented in the program.

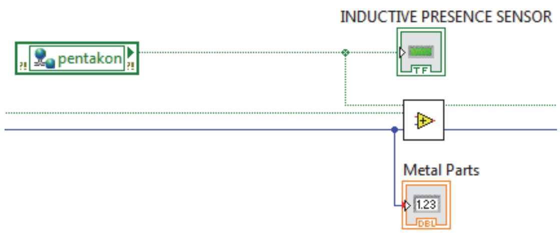

Figure 10: Code of the increment of metal parts counter.

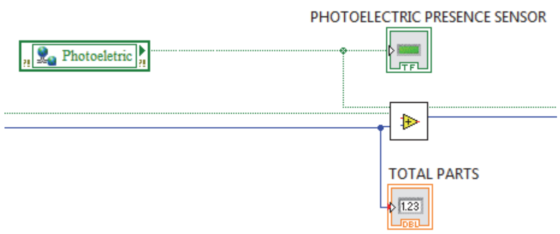

Figure 11: Code used for the increment of the total parts counter.

4.1.3 Bero Inductive Sensor Monitoring

The operation of the inductive Bero sensor could be seen approaching a metal part gradually. According to the proximity of which a metal object is the sensor will generate combinations of bits "1" and "0" which will enable different outputs of the PLC according to the object proximity.

The inductive Bero sensor is the end of the conveyor belt and is monitored by the LED panel located at the bottom center of the VI, indicating the proximity of a metallic object of this sensor, progressively completing the lights of LEDs as the object approaches going Green (5mm) through to yellow (4mm) and orange (3mm), to red when the contact part with the sensor occurs.

4.1.4 Remote Laboratory

A remote laboratory is defined as a computer-controlled laboratory that can be accessed and controlled externally over some communication medium (National, 2006). In this paper, a remote laboratory is an experiment, demonstration, or process running locally on a LabVIEW platform but with the ability to be monitored and controlled over the Internet from within a Web browser using the interface in Figure 9.

The acquisition is still occurring on the host computer however the remote user has the total control. Other users can report their Web browser to the same URL to monitor the application in progress but only one client can control the application at a time. At any time during this process, the operator of the host machine can assume control of the application back from the client currently in control functionality.

5 CONCLUSIONS

In this paper are presented the advisability of using technology tools for auxiliary the process of distance learning, for example, a hypertext which simulates (emulates) a virtual laboratory for realization of on-line experiments.

The discussed experiments attempted to report to the students the concepts involved in this paper using the computer as a main tool for performing and analyzing experiments.

The innovative use of technology applied to education, and more specifically, the distance education, must be supported by a philosophy of learning which provides the students the opportunity to interact, to develop joint projects, to recognize and respect different cultures and to build knowledge.

By the use of the LabVIEW software, students could follow the progress of sensor's activity as well as the network communication process. The code used the processed data to build control logic to perform varied tasks and analysis. This showed how suitable is the system with different applications and approached the student to the real industrial automation process.

Also, the flexibility of iteration between students and teacher provided by technology tools establishes a new dynamic of teaching. The students can better organize your questions and subjects under study and they have the initiative to find their answers.

ACKNOWLEDGEMENTS

The authors would like to thank the CNPq for financial support and everyone from the LIEC (Electronic Instrumentation and Control Laboratory-UFCG) who supported the development of this work.

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Learning Analytics as a Metacognitive Tool

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Keywords: Learning Analytics, Educational Data Mining, Self-directed Learning, Self-Regulated Learning.

Abstract: The use of learning analytics is entering in the field of research in education as a promising way to support learning. However, in many cases data are not transparent for the learner. In this regard, Educational institutions shouldn't escape the need of making transparent for the learners how their personal data is being tracked and used in order to build inferences, as well as how its use is going to affect in their learning. In this contribution, we sustain that learning analytics offers opportunities to the students to reflect about learning and develop metacognitive skills. Student-centered analytics are highlighted as a useful approach for reframing learning analytics as a tool for supporting self-directed and self-regulated learning. The article also provides insights about the design of learning analytics and examples of experiences that challenge traditional implementations of learning analytics.

1 INTRODUCTION

The use of "big data" tools and methods is a growing phenomenon in various fields ranging from computer science, political science, medicine and economics to physics and social sciences. "Big data" analytics refers to the process of examining these large amounts of data to uncover hidden patterns, unknown correlations and other useful information. Its rise coincides with new management and measurement processes in corporations that aim to develop "Business Intelligence" (BI) by transforming raw data into meaningful information that supports more efficient decision-making processes).

In the education sector, analytics are also perceived as reliable tools for decision-making, as well as for achieving greater levels of adaptation and personalization that are evidence-based (Harmelen and Workman, 2012). Beyond BI, analytics in education borrow techniques from different fields, such as Educational Data Mining (EDM), Social Network Analysis, web analytics and Information Visualization in order to come up with tools and methods that facilitate the exploration of data coming from educational contexts. According to Harmelen and Workman, the main potential uses of analytics in education are (p.5):

- "Identify students at risk so as to provide positive interventions designed to improve retention.
- Provide recommendations to students in relation to reading material and learning activities.
- Detect the need for, and measure the results of, pedagogic improvements.
- Tailor course offerings.
- Identify teachers who are performing well, and teachers who need assistance with teaching methods.
- Assist in the student recruitment process".

EDM and Learning Analytics (LA) are two research areas with strong similarities. Both of them seek to improve education by focusing on assessment, the identification of problems and interventions. The main differences can be found in EDM's emphasis on automated discovering and automated adaptation, whereas LA seeks to inform and empower instructors and learners in order to better leverage human judgement (Siemens and Baker, 2012).

LA research has been applied in two close and related areas: learning and academia. Although both of them use educational data, it is important to make a distinction since the underlying motivation of each one varies to great extent. According to the Society for Learning Analytics Research, Learning Analytics can be defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs. Learning analytics are largely concerned with improving learner success" (SoLAR, 2013, About). On the other hand, academic analytics could be described as more business-oriented, since the main purpose is to improve organizational effectiveness through the use of learner, academic and institutional data.

Lately, the high proportion of computer-mediated interactions in learning has created an interest about how data collected from the interactions can be used to improve teaching and learning. In this regard, the increasing offer of Massive Open Online Courses (MOOCs) can be presented as a case in which institutions take advantage of data generated online in order to achieve a better understanding of how people learn. Despite its positive aims, LA still poses questions about how learners can benefit from the data they are generating in such learning platforms.

2 LEARNING ANALYTICS FOR FOSTERING SELF-DIRECTED AND SELF-REGULATED LEARNING

In the knowledge society, self-directed learning (SDL) and self-regulated learning (SRL) have become particularly important for professional development and lifelong learning.

SDL is an approach in which learners take control of their own learning processes and experiences. Tan et al. (2011) describe the processes of SDL based on a series of requisites or qualities: a) ownership of learning; b) self-management and self-monitoring and c) extension of own learning. The authors argue that providing opportunities to establish and control one's own learning objectives, as well as to direct and monitor the associated educational tasks, helps increase the subject's motivation and commitment to learning.

SRL is a process controlled by learners that may be supported by social and environmental stimuli related to setting objectives, self-monitoring progress, searching for help, feedback, self-directed reflection, time management and planning, etc. According to Zimmerman's (1989) definition, self-regulation is conditioned by students' active involvement in metacognitive, motivational and cognitive areas, in their own learning processes. Self-regulation is very much a metacognitive activity and a useful model to help understand metacognition. According to Pilling-Cormick and Garrison. (2007), metacognition goes to the core of both SDL and SRL and is a link or bridge between reflective inquiry and strategic task control.

The concepts of SDL and SRL are so similar that on many occasions they have been used as synonyms. Furthermore, the models proposed in both approaches have many elements in common. Loyens, Magda and Rickens (2008) conducted a complete analysis of the similarities and differences between the SDL and SRL models. Both imply learners' active involvement and goal-focused behaviour. In addition, a series of activities can also be identified as implicit in both models: setting goals, analysing tasks, implementing the plan and self-evaluating the learning process. According to Loyens, Magda and Rickens (2008), the difference between SDL and SRL basically relates to the perspective adopted when studying learning processes, depending on whether attention is focused on the personal attributes and actions of the learners and/or on the characteristics of the learning environment. While SDL encompasses both perspectives, SRL focuses more on the personal characteristics and behaviours of the person or people learning, including the cognitive, behavioural and also emotional dimensions. One possible explanation for this difference is the fact that while SRL has been studied above all in an academic context, the origins of the SDL concept lie in studying adult learning in non-formal environments.

In recent years, particular attention has been paid to the use of technology to support processes of SRL and SDL. The design of digital environments to support SDL and SRL processes aims to offer specific help to learners for planning, organizing and directing their research and exploration, as well as for evaluating their own progress. Bartolomé and Steffens (2011) propose a series of criteria that technology-enhanced learning environments should meet in order to support SRL processes: a) encourage learners to plan their own learning activity, including aspects linked to time management (e.g. when to carry out an activity and how long to spend on it), selecting communication channels and ways of representing information and using of the most suitable resources, b) provide feedback on performance in learning activities to aid monitoring and the correct direction of the learning process and, c) provide learners with criteria for evaluating the results of their learning in terms of the objectives that were initially set and the type of competences developed.

In order to successfully self-regulate and self-direct learning it is necessary that students achieve an understanding of their own cognitive process.

Metacognition, understood as the knowledge of one's own thinking, is a central concept in self-regulation and in self-directed learning since it brings together central constructs of motivation, management and monitoring (Pilling-Cormick and Garrison, 2007). In this regard, Learning Analytics can be a tool that offers opportunities to reflect about learning and develop metacognitive skills.

Feedback has been considered as a key tool for helping students improve performance. Traditional feedback usually relates to learners' mechanisms of communication with their teachers and colleagues. The use of technology adds new possibilities for tracking learners' activity and offers them more immediate feedback about their learning performance. However, most efforts to use learning analytics focus on providing information for the instructors in order to refine their pedagogical strategies (Knight et al., 2013). Very rarely are students considered the main receivers of the learning analytics data or given the opportunity to use the information to reflect on their learning activity and self-regulate their learning more efficiently.

Despite LA's potential for improving teaching and learning, scholars have expressed concerns regarding the use of analytics in education. The main criticisms deal with the commercialization of the education sector, the use of outdated performance indicators, simplistic uses of artificial intelligence, as well as the ethics of the datasets and how they are used (Slade and Prinsloo, 2013). Furthermore, some authors warn that learning analytics could actually disempower learners by making them reliant on institutional feedback (Buckingham and Ferguson, 2011). Quoting Kruse and Pongsajapan, learning analytics "perpetuates a culture of students as passive subjects – the targets of a flow of information – rather than as self-reflective learners given the cognitive tools to evaluate their own learning processes" (2012, p.2).

In response to the use of LA as a tool at the service of teachers and the institution, an increasing group of scholars have started to advocate for student-centred analytics (Duval 2012; Clow, 2012, Kruse and Pongsajapan 2012). In line with these authors, we consider that learning analytics can and should be used as a tool for reflection and metacognition to support SDL and SRL. In this regard, identifying the main challenges in the design of learning environments that make use of learning analytics to foster reflection is a key aspect. From our perspective, the most urgent challenges to be faced fall in two directions: data and visualization. What sort of data is most meaningful for learners? What types of visualization can foster reflection most successfully?

3 LEARNING ANALYTICS DESIGN

The demand for analytics that truly recognize users' ownership is connected to a broader need for control of the data that, as online users, we are constantly generating. Considering this, student-centred analytics share many aspects with Human-Data-Interaction since, according to Haddadi et al. (2013) "The term Human-Data-Interaction (HDI) arises from the need, both ethical and practical, to engage users to a much greater degree with the collection, analysis, and trade of their personal data, in addition to providing them with an intuitive feedback mechanism" (p.3). In this regard, and in order to support SDL and SRL, learning analytics should provide mechanisms for learners to interact with these systems explicitly. This requires learners to adopt a questioning attitude and take part in the interpretation of the data generated about them, but they must also be offered the means to access, understand and interact with the datasets.

The need for transparency and understandability has also been faced by other areas that are closely related to LA, such as Learner Models (LM). The main difference between LA and LM lies in the type of data monitored and its future use. So, while LA often shows activity data (interaction time in discussion; links in social networks or collaboration tasks; performance data), LM use inferences drawn from interaction in order to create a learner information model that allows the system to be highly personalized and adaptive. The appearance of Open Learner Models (OLM) constitutes an important effort towards making a student's learner model explicit with the aim of fostering self-awareness and enhancing learning and learner autonomy (Bull and Kay, 2008). An interesting case of OLM is MyExperiences (Kump et al., 2012). Here, the model has been designed to show users the inferences about them, as well as the underlying data, through a tree map visualization.

Another area that can provide interesting insights for reframing LA is Personal Informatics (PI). According to Li, Dey and Forlizzi (2010) PI can be defined as a class of systems that allow people to collect and reflect on personal information. In contrast to LA, PI, also known as Quantified Self

(QS), requires the user to take an active role throughout the five stages identified by Li et al. (2010): preparation, collection, integration, reflection and action. PI and QS have supported informal learning in fields linked to sports and health since they offer users opportunities to learn about their progression and undertake new challenges concerning healthy habits. Recently, some scholars have noted that QS approaches can support reflective learning and help people become more aware of their own behaviour, make better decisions, and change behaviour (Rivera-Pelayo et al., 2012; Li et al., 2011; Durall and Toikkanen 2013). One important aspect to note when looking at QS approaches is their voluntary nature. Even if QS is used for monitoring chronic conditions, users who self-track are motivated because they understand the potential benefits that this practice will bring them. In contrast, we cannot say that LA practices rely on the learners' voluntary participation. In this regard, one way of encouraging learners to take an active role in LA would consist of allowing them to choose which data they are going to monitor from a flexible and extendable set of indicators.

Transforming data into knowledge is a cognitive process that can be supported by the way in which data is made available. Information visualization has been recognized as a tool for sense-making (Heer & Agrawala, 2008) since it helps synthesize complex information and facilitates comparisons and inferences (Shneiderman, 1996; Tufte, 1990 and 1997). In the learning field, infovis has already been recognized as a powerful tool for teachers and students, especially through goal-oriented visualizations such as dashboards (Duval, 2011). In this regard, Govaerts (2010) notes that visualizations of the learners' activity has been used to improve collaboration, increase awareness, support self-reflection and find peer learners through social network analysis. Some projects working along these lines are CAMera, a tool for personal monitoring and reporting (Schmitz, 2009) and Moodog , a Moodle plug-in that visualizes data from the activity logs to allow students to compare their progress with others and teachers to visualize the students' activity in the online course (Zhang et al., 2007).

A case study by Santos et al. (2012) using goal-oriented visualizations of activity tracking is an interesting experience of student-centred learning analytics through visualizations. In this case, the overall goal was to enable students to reflect on their activity and compare it with their peers. With this aim, data collected using different tools was displayed in a goal-oriented visualization that allowed students to filter the data by different criteria and to compare it with their learning goals. As the authors state, "linking the visualizations with the learning goals can help students and teachers to assess whether the goal has been achieved" (pp. 143). By enabling learners to filter what they want to visualize, LA can generate metrics that relate to what learners value in their learning process. This way, they will be able to generate their own questions and hypotheses that, later on, can be contrasted through data. Learning analytics can be a great tool for reflection since it offers students the opportunity to revisit past experiences from a different point of view. In order to explain the "new situation", it is necessary that learners recognize their assumptions and change their perspective by building new understandings. However, for reflection to occur, it is important to keep in mind that the situations "observed" must be relevant for learners.

4 CONCLUSIONS

In this article, LA is recognized as a powerful tool for helping students reflect on their learning activity and, therefore, gain knowledge about their learning processes. This is especially important since self-knowledge can be considered as a key metacognitive skill for SDL and SRL. Therefore, in order to truly use analytics to help students become autonomous learners, it is necessary to adopt a student-centred approach.

Nowadays, the value of data requires careful and critical reflection on issues relating to privacy, data analysis, context of use and data ownership. In line with other scholars, we support more transparency and openness in LA (Clow 2012; Kruse and Pongsajapan, 2012) since we are dealing with sensitive information that ultimately belongs to the learners. Therefore, educational institutions cannot ignore the need for transparency and should ensure that learners can see how their personal data is being tracked and used in order to build inferences, and how its use will affect their learning.

LA raises the issue about what is valued in the learning process. Can learning be measured according to, for instance, who logs into the system most often, who engages most in group discussions or uploads the tasks on time? There is a need to rethink how learning indicators are selected and to what extent they contribute to conceiving learning as a process instead of in terms of outcomes (Clow, 2012). In this regard, allowing students to decide what aspects they are going to monitor and analyse could help make LA a tool for reflection on learning processes.

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Reflective ePortfolio System
Development and Assessment in Living Lab

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Keywords: Information System, ePortfolio, Reflection, Living Lab, Assessment, Validation, Verification.

Abstract: Modern technologies, information systems, tools, methods and approaches give us new potentialities to ensure better learning outcomes. One of such systems, which are kept high on the agenda, is ePortfolios. ePortfolio systems are considered as an excellent tool to improve learners' competence levels, critical thinking and reflection. This paper shows an approbation of reflection stimulating ePortfolio system developed by the Distance Education Study Centre, Riga Technical University. Introduced system merges a scope of technological and educational aspects to facilitate system users' better achievements. The author underpins Living Lab research method which was used to approbate new system implementation. Experimental part of the work is proved by verification of the ePortfolio system including necessary statistical data analysis. Approbation results show that the developed algorithmic model ensures the formation and functioning of the reflection stimulating ePortfolio system which has direct positive impact on students' competence development, achievements and learning outcomes.

1 INTRODUCTION

Nowadays technologies and information systems bring new potentialities for both teaching staff and learners. Innovative approaches together with technologies and systems ought to ensure lifelong learning demands. As a result, information system developers have been facing the problems of working up appropriate solutions to facilitate better learning outcomes. One of such systems, which are kept high on the agenda, is ePortfolios. More and more educational organisations all over the world embody ePortfolio systems in their curricula (Timmins, 2008). ePortfolio is considered as an excellent tool to improve information system users' competence levels, critical thinking and reflection.

Usually educators and ePortfolio system developers introduce their experience, approach, methodology, educational tools and systems, which display students' achievements or allow some interaction in the form of blogs, reflection of peers' comments regarding particular tasks, etc. (Barrett, 2009, 2011). However, until this day there is still a lack of comprehensive research activities and data analysis related to measurement of ePortfolio systems effectiveness. Experts in this field suggest evaluating system efficiency by measuring activity evidences of its users; characteristic features of the reflection are underlined as the key components in this case (Haig et al., 2007).

Pursuant to actuality of efficiency studies of ePortfolios and a necessity to improve learning outcomes, conformable purpose of the research was formulated – to develop and approbate reflection stimulating ePortfolio system which would merge a scope of technological and educational aspects to facilitate system users' better achievements.

2 DEVELOPMENT AND ASSESSMENT OF THE MODEL

2.1 Tools and Methods

After completed theoretical investigation (Gorbunovs, 2011) the development of reflective stimulating ePortfolio system was continued by practical research activities. They included the development of appropriate system algorithmic model based on Enterprise Knowledge Development (EKD) Methodology (Kirikova, Stecjuka, 2008), simulation scenarios output (Quinn, 2005) and data flow modelling.

Keeping in mind that Living Lab research method is defined as an environment where information system users evaluate and validate novel systems and technologies (Følstad, 2008), this method was used to assess new ePortfolio algorithmic model. Corresponding prototype was created, validated and verified in Living Lab in 2011/12 and 2012/13 academic year. Statistical data analysis was done by Excel 2010 and SPSS 21 software; Kolmogorov-Smirnov and Mann-Whitney non-parametric tests, statistical hypothesis T-test, and determination of correlations were used.

Additionally, positive feedback regarding system impact was received from particular scientific field experts at the international scientific conferences and domestic seminars. Several inquiries were organised also after each completed course to make out students perceptions and their thoughts about used information system's effect on their reflection and competence levels improvement.

2.2 Model Development

Based on an idea that humans do like teach others rather learn themselves (Adler, 2013), as well the statement that Living Labs involve users in the innovation, knowledge sharing, exploration, experimentation, assessment, and co-creation process (Pallot, 2009), respective algorithmic model was developed (Fig.1). It enables group formation, self- and peer-assessment within groups, responsibility for own attitude, activation of critical thinking and reflection, and as a result – improvement of learning outcomes.

First of all, it is necessary to specify that university's learning and content management system (LCMS) and created ePortfolio system are two independent information systems. Activities within ePortfolio system are available when system administrator or course tutor manually copies fulfilled homeworks from the LCMS data base to ePortfolio system.

Before ePortfolio system enables any activities, students fulfil first assignments: take a test to assess initial level of their competences, make self-appraisal and submit first homework. All these data go into university's LCMS data base. After submission of the homework at the first onset the tutor inputs it to ePortfolio data base. Based on a time sequence of submitted homeworks, ePortfolio system forms groups of four students each (Fig.2).

Activities in ePortfolio system start with user's authentication and authorization. Login files data are collected in ePortfolio data base. Students assess other group members' homeworks in a form of suggestions and scores in the scale from 1 to 10, where 1 is the lowest estimation and 10 – the highest one.

The same procedure applies on self-assessment of own homework. Both approaches stimulate

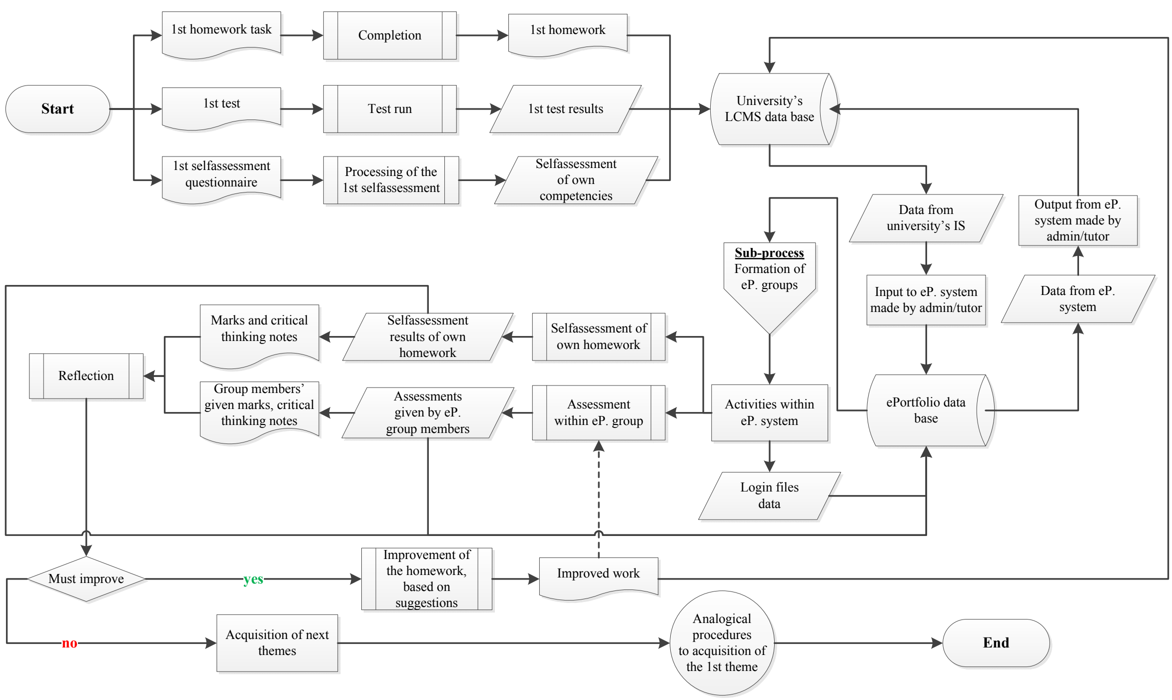

Figure 1: Reflection stimulating ePortfolio system's algorithmic model.

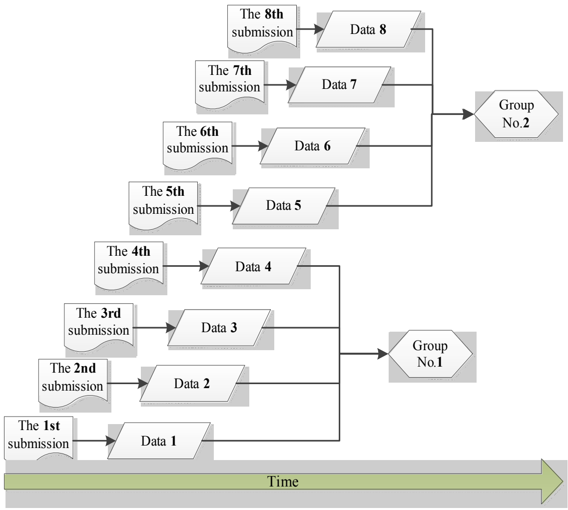

Figure 2: Group formation within ePortfolio system.

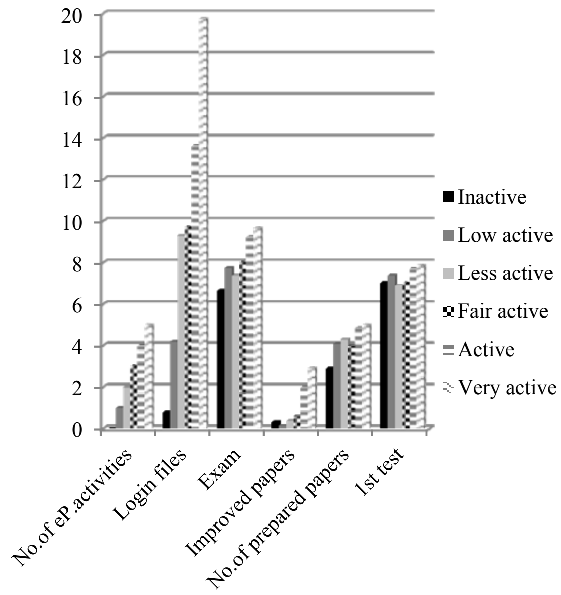

Figure 3: Learning outcomes depending on activities within ePortfolio system.

reflection and impact an improvement of previous documents. Based on peers made evaluation the student takes steps to improve own homework and proceeds to the next course module, or, if he/she decides that there is nothing to be improved in the homework, peers remarks are taken into account and the learner also proceeds to the next course module.

During 2011/12 and 2012/13 academic year all improved papers were sent to university's LCMS. However, the algorithmic model allows developing in future another prototype which would return all improvements back to ePortfolio group collaborative environment for reviewing.

2.3 Assessment of ePortfolio System in Living Lab

2.3.1 Validation

To validate the first developed ePortfolio system model, an appropriate prototype was built and approbated in 2011/12 academic year at Riga Technical University. Approbation results in Living Lab show effectiveness of the system which stimulates system users' reflection and improves particular to the course competence levels (Fig.3). It was concluded that the improvement of learning outcomes, i.e. competence levels (measured by exam results), reflection (measured by a number of improved papers) and accomplishments outside the system (measured by a number of prepared papers), were directly dependent on system users activities within the system, i.e. fulfilled tasks in group-working activities and login files.

ePortfolio system users survey results also demonstrate system's importance on improvement of learners competence levels (Fig.4) and reflection (Fig.5). Considering that these surveys were organised apart, the number of respondents vary.

In the first questionnaire students were asked to mark in the scale from 1 to 10 (from the worst answer to the best one, i.e., mark "1" meant that the system had not an impact, mark "2" – the impact was negligible, mark "10" – the system had the most impact), how much ePortfolio system improved their competence levels.

112 users participated in this survey. Majority of them – 77 learners (or 68 per cent) had a strong confidence about system's (or 10 per cent) – held a view that the system had a minor impact on their competence improvement, and only 3 participants (or less than 3 per cent) said that they did not notice any system's impact.

In the second questionnaire students were asked how much ePortfolio system improved their reflection abilities. From 116 users participated in this survey majority – 103 respondents (or 88 per cent) had a strong confidence about system's positive impact on their reflection, 12 students (or 11 per cent) ware rather satisfied, and only 1 learner (or less than 1 per cent) admitted unsubstantial impact of the system. There was nobody who would say that the system did not improve his/her reflection abilities.

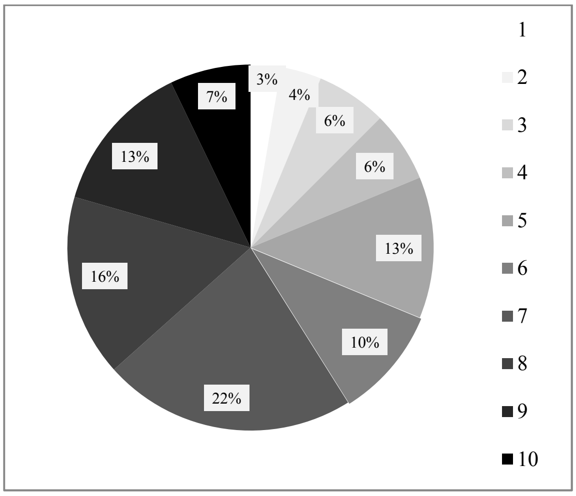

Figure 4: Users' opinions related ePortfolio system's impact on their competence improvement.

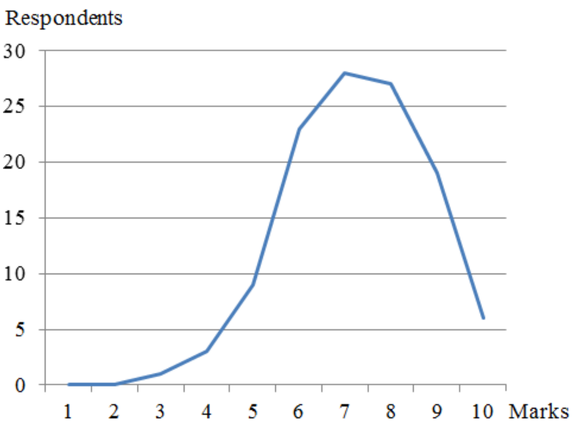

Figure 5: Users' opinions related ePortfolio system's impact on their reflection.

2.3.2 Verification

To find relationship between input and output parameters of developed ePortfolio system, representative sample of 145 students was ranked discrete into two groups: non-users group (20 students) and experimental group – ePortfolio system users with at least one login (125 students). There was impossible to set up equal quantitative structure of both groups due to a principle of voluntary participation in research activities.

To find competence distribution in whole sample and within groups, Kolmogorov-Smirnov test was used to prove null hypothesis H0 - competence distribution within group forms normal distribution, and alternative one Ha - competence distribution within group does not form normal distribution.

Table 1: K-S test for the whole sample.

		Initial test	Exam
N		145	145
Normal Parameters[a,b]	Mean	7,5176	8,05
	Std. Deviation	,85006	1,883
Most Extreme Differences	Absolute	,085	,207
	Positive	,041	,155
	Negative	-,085	-,207
Kolmogorov-Smirnov Z		1,022	2,493
Asymp. Sig. (2-tailed)		,247	,000

The distribution of initial competences (initial test) for whole sample forms normal distribution (Table 1) – as asymptotic significance 0,247 > 0,05 and test value does not exceed critical values, the hypothesis H_0 is affirmed with 95% level of confidence. The distribution of final competences (exam) at the end of the course does not form normal distribution – as asymptotic significance 0,00 < 0,05, the hypothesis H_0 is not affirmed. Wherewith, it confirms the impact of created ePortfolio system on users learning outcomes.

Table 2: K-S test for experimental group.

		Exam	Initial test
N		125	125
Normal Parameters[a,b]	Mean	8,43	7,5543
	Std. Deviation	1,278	,82982
Most Extreme Differences	Absolute	,200	,074
	Positive	,152	,058
	Negative	-,200	-,074
Kolmogorov-Smirnov Z		2,231	,826
Asymp. Sig. (2-tailed)		,000	,502

During Kolmogorov-Smirnov test for experimental group (Table 2) it is found that as asymptotic significance of initial test 0,502 > 0,05, and test value does not exceed the critical one, the null hypothesis H_0 is affirmed with 95% level of confidence. It means that the distribution of initial competences for experimental group forms normal distribution. The distribution of final competences does not form normal distribution – as asymptotic significance 0,00 < 0,05, the null hypothesis H_0 is rejected. Analysis for each separate login file was not made due to excessive number of login files (from 1 to 38) and insufficient number of users in each. Consequently, the distribution of achieved competence levels at the end of the course does not form normal distribution in active users' experimental group. However, as soon as we start analysing users activity within the system, exponential distribution appears. We can conclude that the more the user logins the better results he/she achieves.

For comparing mark distribution in two populations (non-users and experimental ePortfolio system users group) Mann-Whitney nonparametric test was used (Table 3) to test null hypothesis H_0 that competence distribution in both populations have identical distribution functions against the alternative hypothesis H_a that competence distribution in two distribution functions differs.

Table 3: Mann-Whitney test.

	Initial test	Exam
Mann-Whitney U	1095,000	356,000
Wilcoxon W	1305,000	566,000
Z	-,890	-5,284
Asymp. Sig. (2-tailed)	,374	,000

a. Grouping Variable: dd

During Mann-Whitney test it was found that: as asymptotic significance of initial test 0,374 > 0,05, the null hypothesis H_0 is affirmed with 95% level of confidence. It means that distribution of initial competence levels in both non-users and users' groups is identical. As asymptotic significance of exam (i.e. achieved competence levels at the end of the course) 0,00 < 0,05, the null hypothesis H_0 is rejected, and alternative hypothesis H_a is affirmed – distribution of final competence levels in two groups differs. It could be concluded that experimental group, which took part in ePortfolio activities, achieved better results than non-users group.

For comparing significant difference of arithmetic means between two groups (experimental and non-users ones) the T-test was used (Table 4). As the T-test value -1,304 does not exceed critical values, with 95% level of confidence we can conclude that both groups have the same on average initial competence level (average initial competence level value-judgement of non-users is 7,29 and users – 7,55). But, as the T-test value -7,112 exceeds critical values, with 95% level of confidence we can conclude that there is a difference in achieved competence levels at the end of the course between non-users and users groups (average final competence level value-judgement of non-users is 5,65 and users – 8,43). Namely, ePortfolio system users achieve better learning outcomes (i.e. competence levels) than non-users.

To find relationships, their strength and way between input and output parameters, the correlation coefficients were calculated. It was found that:

- There is a moderate positive correlation between activities within ePortfolio system and the number of improved homeworks – the main parameter of reflection (correlation coefficient r= 0,492, correlation is significant at the 0.01 level (α= 0,01));

Table 4: T-test.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Initial test	Equal variances assumed	,484	,488	-1,304	143	,194	-,26632	,20423	-,67001	,13737
	Equal variances not assumed			-1,174	23,781	,252	-,26632	,22675	-,73454	,20190
Exam	Equal variances assumed	26,073	,000	-7,112	143	,000	-2,782	,391	-3,555	-2,009
	Equal variances not assumed			-4,048	20,095	,001	-2,782	,687	-4,215	-1,349

- There is a moderate positive correlation between activities within ePortfolio system and achieved competence levels at the end of the course (r= 0,475, α= 0,01);
- There is a moderate positive correlation between activities within ePortfolio system and fulfilled external tasks (r= 0,613, α= 0,01);
- There is a moderate positive correlation between activities within ePortfolio system and login files (r= 0,454, α= 0,01). At the same time there is weak correlation between activities within ePortfolio system and initial test results (r= 0,169, α= 0,05). As a result, it could be concluded that approbated ePortfolio system has considerable impact on learners' activities apart from initial competence levels;
- There is also a positive correlation between the number of login files and the number of improved homeworks (r= 0,356, α= 0,01), as well achieved competence levels at the end of the course (r= 0,269, α= 0,01);
- There is a weak positive correlation between initial test results and the number of improved homeworks (r= 0,129), as well exam results (r= 0,258, α= 0,01). It could be concluded that ePortfolio system impacts its users' competence development and reflection improvement apart from initial competence levels.

2.3.3 Assessment of Modified Model

In contradistinction to the first version of developed ePortfolio system, where group composition remained unchanged from initial ePortfolio activity till the end of the course, its modified version provides group formation anew for each activity module.

Due to the fact that the university's LCMS and ePortfolio system are two independent information systems, partial automation was made. Namely, course instructor regularly downloaded all students' papers into one directory (c:\ePortfolio). The system divided these files into groups – registered submitted papers (files) and group numbers in ePortfolio system data base. New approach and implementation of automation tool ensured regular group completing and permanence of quantitative structure, although the amount of all groups was decreased.

To validate modified ePortfolio system model, an appropriate prototype was built and approbated in 2012/13 academic year at Riga Technical University. Approbation results in Living Lab show again effectiveness of the system.

Like in previous year, survey results regarding modified system's impact on users' competence improvement and reflection development mainly displayed students' confidence about system's positive impact on their reflection and competence improvement.

At the model's verification stage to find relationship between input and output parameters of modified ePortfolio system, representative sample of 99 students was discrete ranked into two groups: non-users group (18 students) and experimental group – ePortfolio system users with at least one login (91 students).

After completion of Kolmogorov-Smirnov, Mann-Whitney and T-tests, as well determination of possible correlations, it was observed that tests' results are similar to previous ones made for the first prototype in 2011/12 academic year. However, comparison and analysis of correlation coefficients in both cases gave some suggestions regarding efficiency of developed systems. Thus:

- There is a moderate positive correlation between activities within modified ePortfolio system and the number of improved homeworks – the main parameter of reflection ($r= 0,446$, $\alpha= 0,01$);

- There is a moderate positive correlation between activities within modified ePortfolio system and achieved competence levels at the end of the course ($r= 0,565$, $\alpha= 0,01$);

- There is a moderate positive correlation between activities within ePortfolio system and fulfilled external tasks ($r= 0,493$, $\alpha= 0,01$);

- There is also positive correlation between the number of login files and the number of improved homeworks ($r= 0,304$, $\alpha= 0,01$), as well achieved competence levels at the end of the course ($r= 0,393$, $\alpha= 0,01$);

- There is no correlation between initial test results and the number of improved homeworks ($r= 0,023$), as well exam results ($r= 0,070$). It could be said that ePortfolio system impacts its users' competence development and reflection improvement apart from initial competence levels.

3 CONCLUSIONS

Approbated ePortfolio system encourages learners' reflection, which is the part of critical thinking process, and is realised through feedback links, enables competence levels improvement, enhance learning outcomes, and stimulates activities also outside the system.

This model ensures system users' active availability for work and participation in group-working activities to develop own reflection and competence levels. This could be done through collaboration with peers within ePortfolio groups by assessing group members' papers and suggesting them necessary improvements, as well by thinking critically on the own accomplishments. Reflective approach brings new attitudes and better learning outcomes.

Based on test results it might be concluded that modified ePortfolio system has greater impact on its users' competence levels improvement than previous system (accordingly, $r= 0,565$ against $r= 0,475$). On the other side, the first developed ePortfolio system has better results than modified system version in facilitation of users' reflection (accordingly, $r= 0,492$ against $r= 0,475$) and fulfilled external tasks outside the system (accordingly, $r= 0,613$ against $r= 0,493$).

Developed ePortfolio system algorithmic model could be used as a base for creation of further modifications of reflection and competence enhancement information systems.

Living Lab research method ought to be considered as an excellent approach to validate and verify information system models in educational environment.

ACKNOWLEDGEMENTS

This work has been supported by the European Social Fund within the project «Support for the implementation of doctoral studies at Riga Technical University».

The author is very grateful to Dr. Sarma Cakula, the professor of Vidzeme University of Applied Sciences, for provided constructive recommendations and comments regarding possible improvements of this paper.

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A Study of the Acceptance of Facial Authentication in Distance Education in Different Spanish Speaking Countries

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Keywords: Face Recognition, Online Learning, Analysis of Perceptions, Educational Results, Biometrical Recognition, Tools Moodle.

Abstract: Accurate student identification has usually been considered important in the field of e-learning. Nowadays, there are several technologies to identify students and one of them is facial authentication (by means of biometrics), which allows user identities to be authenticated and verified based on their physiological features of their faces. There is actually a high demand of students wanting to gain admission to e-learning programs. Therefore, it is crucial for this kind of education to be as adequate and recognized as any other. For this purpose, it is necessary to verify the students' identity when they are doing their homework using the Learning Management Systems (LMSs) such as Moodle platform. The main objective of this research is to analyze student perceptions about the development and implementation of facial authentication for e-learning within the Moodle platform in different Hispanic speaking countries (Spain, Dominican Republic and Colombia).

1 INTRODUCTION

Like Arenas, Domingo, Molleda et al. (2009) mention, universities are on the way to transform a classic teaching model into a new mixed teaching model, combining distance learning and face-to-face learning. Distance learning is commonly also called distance education and e-learning. Toth, Pentelenyi and Toth (2008) affirm that e-learning is a new kind of interactive learning in which the learning content is available through the network and, therefore, provides an automatic feedback about teaching activities for the students. Llamas (1986) establishes that e-learning can be explained as the ways to study that are not instructed or monitored directly in the presence of a teacher in class, but benefit from the tutors' planning and guidance through a mean of communication that permits the interrelation among students and professors.

Currently, there is a big demand for admissions into e-learning university degrees. Consequently it is necessary for distance education to be as acceptable as another sort of education. In order to achieve this requirement, it is needed to certify the students' identity when they do their exercises within the Moodle platform (Dougiamas and Taylor (2003)), and thus, should be able to avoid educational frauds. In this sense, Moodle has turned into one of the most used platforms in universities as a preferential way to encourage interactions between professors and students (Çelik, 2010).

It is fundamental to delimit what biometrics is, to be able to implement this procedure of verification. As Jain and Flynn, (2008) indicate, biometrics is a method for recognizing people based upon physiological or behavioral characteristics. There are different typologies within biometrics, such as fingerprints, iris, voice, facial verification (García-Hernández and Paredes, 2005).

There have been some attempts to solve people authentication having in mind physical aspects of the human body, but it is through facial authentication (Tapiador, 2005) where it appears an opportunity in e-learning to verify the absence of frauds while the students do their activities on the platform. As Duró (2001) states, face-based authentication corresponds to a system that allows the identification and/or verification of a person's identity as of the morphological or behavioral characteristics, unique to each individual.

From the other side, the Project we are working in has focused on the perception Master Degree students from different Hispanic speaking countries have had with the implementation of face-based authentication in the Open University of Madrid (UDIMA) within the Moodle platform. A questionnaire was produced for the development of the project in order to know the perceptions of the students.

2 RELATED WORKS

Lately, new information and communication technologies have merged with e-learning through the Moodle platform. The focus of our attention will be on the best renowned articles about the acceptance that facial authentication could have in different geographic regions on the platform Moodle.

Domínguez (2010) ran an article about Moodle platform in the world; regarding our territory, Spain is placed at second position throughout the world, before the United Kingdom and behind the USA. This analysis concludes that countries like Colombia or Dominican Republic are not amongst the top 10 countries with registered Moodle sites.

Rama (2010) analyzed the percentage of e-learning enrollments compared to the other kinds of education. As it can be perceived in the article, e-learning in higher education hardly reaches 10 percent of the whole Colombia enrollment. With respect to the Dominican Republic, the e-learning modality represents 11 percent of the country institutions and 6.26% of the total amount of students in the country. Comparing these data to Spain's, 15 percent of Spanish students study at the National Distance Education University (UNED), hence the fact that it is possible to assure that at least 15 percent of students are distance learning students. Moreover, the real percentage will be higher due to there are new private universities having distance education programs in Spain (UDIMA, UOC, Universidad de Cantabria, etc.) but there are not enough data to estimate the percentage of population that study at these Spanish universities

Besides et al., (2008) completed the investigation about the implementation of facial verification into Spanish education with a successful positive result. The goal they pursued was to guarantee that the students in line are who they say they are, and to know exactly the amount of time that they spend in front of the computer reading or realizing their virtual activities. In the same way of face-based authentication, Ullah et al., (2012) posed a facial authentication mechanism in order to ensure that the students are not impersonated to improve their marks in virtual tests. Lastly et al., (2011) presented a system to check that the students are really attending virtual classes through physical biometric characteristic (face features).

On the other side, there are numerous researchers that use the webcam of computers or laptops of the students in their methods to extract images of them, to subsequently proceed with using facial authentication as of those pictures. Along these lines, there are works as Pattanasethanon, Savithi (2012) or for instance, those from the researchers Grafsgaard et al., (2013) from the North Carolina State University. They developed an investigation about the software of recognition of facial expressions where the emotions of on-line students can be evaluated with accuracy and predict the effectiveness of the tutorial sessions through the video camera of their webcam.

When comparing these analyses to ours, the main difference is that our research is focused on knowing the percentage rates that the development and the implementation of facial recognition in different Hispanic speaking countries.

3 MOTIVATION

Until now, the way of working of the students in distance education was not controlled considering that there were not any way to monitor in which situation they developed their activity. The use of this technology within education raises the possibility to verify that there are not frauds while students do their activities on the platform.

The purpose of this investigation is focused on knowing the degree of valuation and usability that the implementation of face-based authentication in e-learning through the Moodle platform in different Hispanic speaking countries, like Spain, the Dominican Republic and Colombia has in university students. To put it in another way, it is expected to know the students opinions and attitudes from each country, comparing with the remaining ones and a scale with the degree of acceptance about which kind of activity (continuous assessment, learning activities, tests) is more valued for the implementation of the tool in distance education.

The SMOLW tool was implemented as facial recognition software for the research development. It consisted of capturing photos of the student for his subsequent webcam verification. SMOWL was inserted when the student used to insert contents in glossaries and to do tests of the different lessons of the subject.

4 ANALYSIS OF THE PERCEPTION OF STUDENTS ABOUT FACIAL RECOGNITION

The poll had a size of 56 students from the course ‘Advanced techniques in E-Learning’ from the Master Degree on Education and New Technologies and from the course ‘Technology Platforms’ from the Master Degree on Digital Communication of the Open University of Madrid (UDIMA). The sample of respondents was composed of 50% of Spanish students and the rest 50% of Latin American students, in particular from Colombia and the Dominican Republic. The Spanish average age was 32.54, being 64.28% women and 35.71% men. On the other hand, the average age in Latin America was 36.75 with the same percentage of women and men.

The collection of data is another important step in the investigation since the conclusions of a study are based on such data. In most investigations, when assessing attitudes and opinions, the seven-point Likert scale is usually used: Totally disagree(1), Disagree (2), Slightly Disagree (3), Neither agree nor disagree (4), Slightly Agree (5), Agree (6) and Strongly Agree (7). The questions of the current research are answered with this scale.
Among all those questions that have been conducted, the most valuable in terms of content has been highlighted. Table 1 presents these questions, which have been raised with the Likert scale:

Table 1: Questions of the questionnaire.

	Question
1	After testing the software, do you think it is a good method to identify people?
2	Do you think it is appropriate to use facial authentication in e-learning?
3	Do you think it is fair to monitor distance education in order to avoid cheating?
4	If you could choose, would you rather realize the activities with the incorporation of this software in order to demonstrate that you have done the activity, and not be harmed in front of students that ask others to do their activities?
5	Do you think the use of this software could have caused a rise of your academic efficiency when you have been doing your activities?
6	Do you think you have taken the same time to do your activities when you knew your identity was being verified?
7	Do you think it is appropriate to apply facial authentication to the tests?
8	Do you think it is appropriate to apply facial authentication to the activities of continuous assessment?
9	Do you think it is appropriate to apply facial authentication to the learning activities?

5 RESULT OF THE ANALYSIS

In relation to the knowledge the participants of the study have about the implementation of face authentication in e-learning in different countries, it is noticeable that there are quite positive average values. Related and gathered data have been attached to the Figure 1, in order to start analyzing the impact achieved, as well as all the questions suggested in the questionnaire. Each question is presented with the average of all the respondents to have a general view. It is useful to recall that number 1 would be ‘Totally Disagree’ and on the contrary 7 ‘Strongly Agree’. Also, it is necessary to have in mind that ‘SPA’ refers to Spain and ‘LAT’ to Latin America.

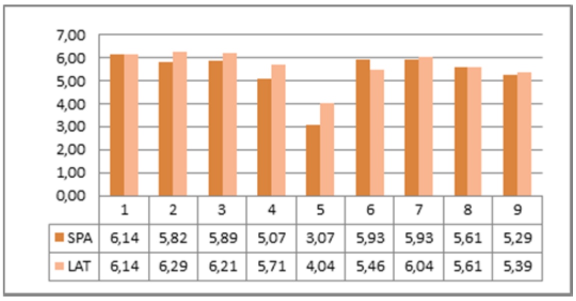

Figure 1: Average responses of all the questions with the seven-point Likert scale.

If the responses of the figure 1 are analyzed for the two geographic group of students, one can observe that the use of the tool has a good acceptance in the whole geographic area that has been investigated. Although on the other hand, when analyzing the gathered data from the investigation for all the questions depending on the different geographic areas, one realizes that the implementation of facial authentication has more acceptance for the students from Latin America.

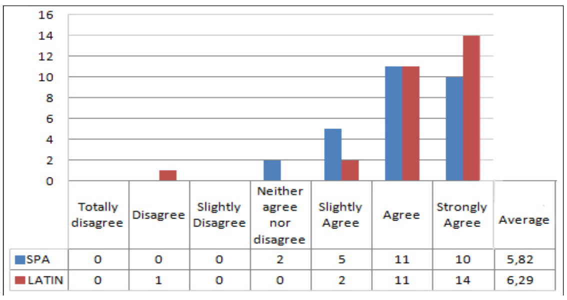

Figure 2: Do you think it is appropriate to use facial authentication in e-learning?

It is clear that for all the respondents of the

Figure 2 it is necessary the implementation of SMOWL in e-learning. Although, if the question is analyzed by areas, we find that Latin America gives a better reception and approval than Spain. If the different averages are observed, it can be seen that Latin America has an acceptance average of 6.29 out of 7 in contrast with 5.82 out of 7 of Spain.

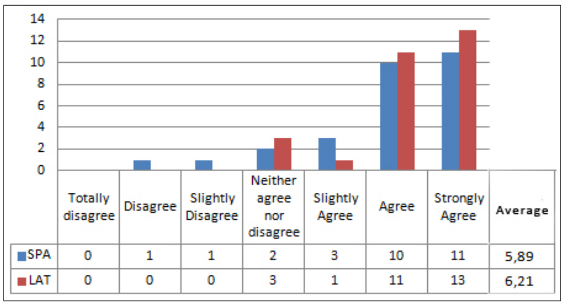

Figure 3: Do you think it is fair to monitor distance education in order to avoid cheating?

In Figure 3, it is clear that for almost all the people replying the survey, it is fair to control who performs the tasks and who is a fake user. In fact, one can observe that almost all respondents agree or strongly agree with this proposal. Only two learners disagree with it. If one compares between countries, one can observe that it is perceived as fairer by learners from Latin America.

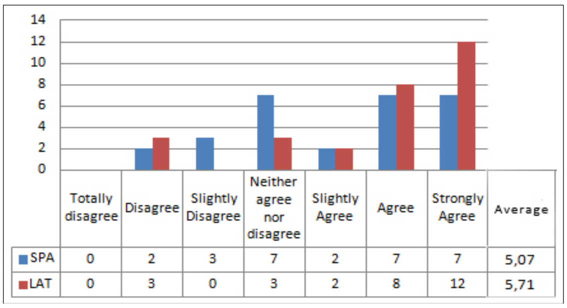

Figure 4: If you could choose, would you rather realize the activities with the incorporation of this software in order to demonstrate you have done the activity, and not be harmed in front of students that ask others to do their activities?

In figure 4, we can see again how the students from Latin America are more willing to accept the use of facial authentication in online classes. One can tell intuitively that Spanish students resist the idea of these new technological methods. If we take the average of both areas, it is possible to see how Spain has an average of 5.07 while Latin America has 5.71.

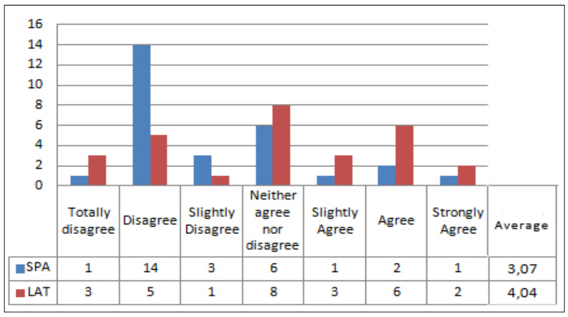

Figure 5: Do you think the use of this software could have caused a rise of your academic efficiency when you have been doing your activities?

In figure 5, It is obvious that Latin American students have different more different opinions than Spanish learners and also there are not an answer that prevails in the rest of the options. From the average, Spanish students disagree with an average of 3.07 in relation to the average of 4.04 from Latin America. From this, it can be deduced that Spanish students think that the use of facial authentication does not help improving the efficiency when doing their activities, as they think they have been able to work in the same way as they would have worked without the tool.

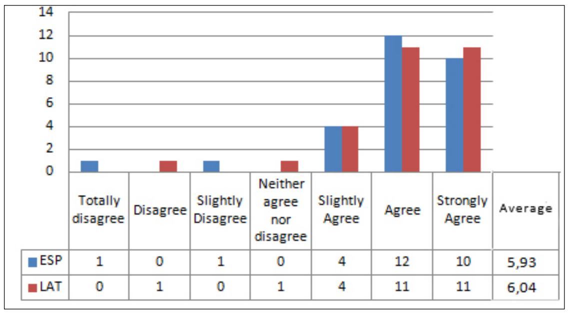

Figure 6: Do you think it is appropriate to apply facial authentication to the tests?

In Figure 6, there is a high percentage of students that accept the application of facial authentication to the tests on the Moodle platform. The sample of respondents thinks it is fair to monitor and verify when the student realizes their tests to avoid cheating.

In addition to the implementation of facial authentication in the tests in Moodle, it is also necessary to accomplish the continuous assessment activities, due to this kind of activities is quite important in the course. If the Figure 7 is analyzed carefully with the average, and Latin America keeps the same percentage over Spain.

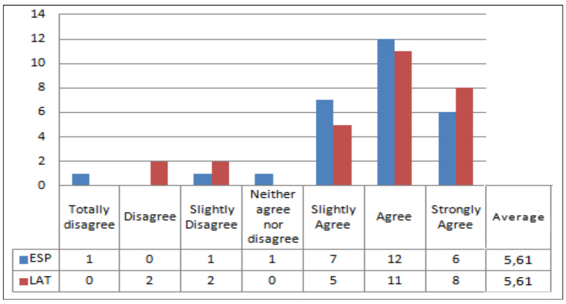

Figure 7: Do you think it is appropriate to apply facial authentication to the activities of continuous assessment?

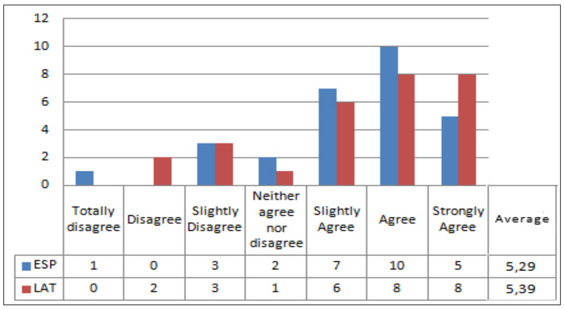

Figure 8: Do you think it is appropriate to apply facial authentication to the learning activities?

With respect to the learning activities, Figure 8 shows that the majority of the students think that learning activities should also include the facial-recognition software, although there are some students that slightly disagree.

On the other hand, if the average about the different typologies of activities we can accomplish in the platform Moodle is analyzed and compared, one can extract the order of preference of students to include facial authentication in the different kinds of activities. For students, the tests are the most important activities to include facial authentication, followed by the continuous assessment activities, and the least important ones are the learning activities.

Without any doubt, the analysis carried through the perceptions of the students from both Hispanic speaking areas shows the acceptance of the tool, although there are differences in the degree of implementation depending on the country. In particular, Latin American countries present a wider acceptance than Spain.

6 CONCLUSIONS AND FUTURE WORK

This section presents the conclusions that have been reached in the development of this project and the results obtained through the presented analysis. In addition, some future work is raised based on this research.

The analysis of the answers of the students revealed that the respondents from Latin America valued the implementation of this tool in distance education more than Spanish students. Moreover, they accepted the tests to be the main activity to be monitored in Moodle.

Comparing and analyzing the data gathered with the work of Rama (2010), one can conclude that Colombia and the Dominican Republic have higher acceptance of the tool, but at the same time there are more Spanish students signed up in distance courses than Latin Americans. One possible reason for this fact can be that Spanish are more used to online education (for now without being monitored in LMSs), and consequently they feel the facial authentication as an intrusive technology that they have not used for many curses. On the other hand, Latin American students have started online education more recently, and they find more appropriate to authenticate the student identities, since they are not still very used to LMSs without biometric authentication.

The work of this survey opens new ways and lines of research with which to continue working in the future. In the first place, it is planned to develop a Moodle plugin for SMOWL accessible for all the education community, in which instructors can configure the activities where they want students to be facially authenticated.

The work is also planned to be extended with more elaborated and extensive questionnaires in order to know the perceptions of the students in both Hispanic areas. Moreover, this research will also include an analysis of the legislation issues about privacy in the different countries. In the future, it is also important to wonder until which point biometrics permits privacy. In fact, we plan to reflect on this aspect, because any technology based on biometrics is traditionally considered to be able to dehumanize and threaten the privacy rights of people.

ACKNOWLEDGEMENTS

This work has been done in the context of the research project *Desarrollo de un módulo de autenticación y monitorización biométrica de usuarios en entornos virtuales de aprendizaje*, supported by the *Universidad a Distancia de Madrid,* with grant UD-019. This research work has also been funded by the Spanish Ministry for Economy and Competitiveness through the project *Social Ambient Assisting Living - Methods* (SociAAL), with grant TIN2011-28335-C02-01.

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Can an Electronic Health Record be Also an Achievable and Sustainable Vehicle for Clinical Staff Training?

The Importance of e-Learning in Medical Education Accomplished in a Real Operational Hospital Context

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Keywords: Electronic Health Record (EHR), Health Care Associated Infections (HAIs), Remote Infectious Diseases Consultations (RIDC).

Abstract: The health care associated infections (HAIs) are growing all over the world. The development of a customized web-technology for Electronic Health Record (EHR) is aimed to answer to the growing need for expert Remote Infectious Diseases Consultations (RIDC) in high-risk settings lacking of Infectious Diseases (ID) specialists and as a tool for the ID students. The outcome measures to evaluate efficacy and efficiency of the web-platform developed for this purposes are the satisfaction of specialists involved; number of RIDC performed compared to historical data; number of bed-side consultancies needed for the insufficiency of web-based data; time spared in avoiding staff movement. In 12 months 18 simulation tests, 19 RIDC and 52 EHR access have been performed for patients admitted in the Cardiac Surgery Unit (L Sacco University Hospital, Milan – Italy). The mean time from the web-call and the RIDC was 2 hours (range 2 min – 16 hours). The major limit of the system is the time for web-form filling for clinical case presentation. Several severe infectious diseases case management histories are already stored for ID students learning. After this first phase considerable structural adjustment are currently under revision.

1 INTRODUCTION

Infectious diseases represent now, more than ever, an important part of healthcare activities involving all clinical and surgical wards.

In recent years the problem of nosocomial infectious diseases or “health care associated infections" (HAIs) has proliferated into a public healthcare priority, both in terms of the adverse consequences to health and to the impact on organizational and financial resources. They affect an estimated 1.7 million hospitalizations in the United States each year, they increase patient morbidity and risk of mortality, the cost of treatment, and they extend hospitalization time (Eber, 2010; Lanini, 2009; Klevens, 2007).

This proliferation has been observed as a steady increase in the emergence and diffusion of severe diseases from multi-drug-resistant pathogen and often attributable to the indiscriminate use of anti-infective drugs (antibiotics, antifungals, antivirals) (Mauldin, 2010; Graves, 2010).

Currently, Infectious Diseases’ specialists (ID specialists) – present only in a limited number of general hospitals - are involved in the management of complex patients hospitalized in high-risk environments such as; surgical wards, intensive and post-operative care units, patients exposed to organ transplantation, onco-hematology patients, etc. Due to their limited numbers, ID specialists currently work in both their designated hospital and also as external consultants in hospitals where the institutional figure of the ID specialist is missing.

Consequently, the organization of consultations activities from experienced professionals has become increasingly difficult as demands and needs invariably grow. Moreover, these activities often terminate as "on and off" performances which, unfortunately, cannot be shared with colleagues in order to promote the enhancement of clinical protocols of intervention on the patient side.

2 A NEW CONCEPT OF REMOTE MEDICAL ADVICE AND E-LEARNING

To address these needs, within the Infectious Diseases (ID) Department of the Teaching Hospital "L. Sacco" in Milan (Italy), an Electronic Health Record (EHR) system was implemented. The implemented system provides the electronic delivery of remote infectious disease consultations (RIDC) to facilitate the diagnostic and therapeutic process in the hospital's operational units where an ID specialist is not directly available.

The innovative component of this portal (Rossi, 2006) enables it to be used, if required, as an educational database of clinical case studies. From this repository, clinical case studies can be readily made available to practitioners and trainee doctors, as well as to a collaborative working environment where professionals from different disciplines can exchange views and feedback on various ID issues.

This system is based on a web-platform that not only permits remote reporting of online consultations on real patients, but also represents an innovative model of e-learning in medical education. This is because access to this consultancy system has been extended to medical specialists who, in accordance with criteria of efficiency, effectiveness and respect for patient privacy and internal guidelines, can study which therapeutic approaches have been adopted by more experienced colleagues when dealing with diseases involving different clinical disciplines.

2.1 Project's Purposes

The project kick-off was in November 2011 and has a duration of 3 years (so it is a work in progress) but is relevant to providing answers to 3 main issues:

1. The continuing increase in demand for ID specialist consultations by physicians who work in environments with a high risk of nosocomial infectious diseases in hospitals that do not have an internal service for infectious diseases;
2. The need to optimize the time required to perform the ID consultations and troubleshooting the infectious criticalities in high-risk patients;
3. Provide an adequate technological setting, working as a clinical database that facilitates distance learning for professionals. In other words, a real portal for the study and evaluation of complex and up to the minute clinical cases.

2.2 Project's Timeline and Methods of Results' Analysis

From the operational point of view the project steps performed can be thus summarized as follows:

- Analytical phase: data analysis needed to develop a platform for ID online consultations;
- Development of the online platform with the help of one of the hospital's principal supplier: definition and customization of pages and online algorithms using active interaction and collaboration among IT analysts and developers and ID specialists in order to test all along the processes and the effectiveness of the product under development;
- Partners' engagement: contacts with other operational units to identify partners interested in participating actively in the first experimental phase, sharing the aims of the project and interactions during the development of the platform. In the pilot project the inpatient operational unit chosen was Cardiac Surgery and Post Operative Intensive Care Units of L. Sacco University Hospital;
- Integration with other hospital applications already in use: meetings between the providers of the online consultations platform and the hospital's IT technicians for the necessary integrations, for example the evaluation of laboratory tests results, radiology images and reports and anatomic pathology reports;
- Evaluation of operational procedures: simulated tests for RIDC calls to verify the accuracy of the logical processes that underpin the ability to make effective consultations, the completeness of the information collected, the information flow, the possibility to manage emergency/urgent situations, the adaptation of privacy rules, data security and integration with the Lombardy regional platform;
- Staff training and education: for ID consultants

and for partners who use the EHR platform;

- Experimental phase: real RIDC activities carried out with the identified technological partner;
- Portal access given to physicians specializing in ID and professionals of other departments (appropriately selected by the Board of Medical Directors) for the evaluation of real clinical cases;
- Check and audit: periodically audits were made during the period of use of the platform, required by the medical staff involved (ID physicians and colleagues who demand online consultations) for the adaptation of the operational processes useful to improve the efficiency and quality of the consultations, the learning process and the training of medical staff with respect to the changes from time to time set up;
- Final assessment (November, 2014) will encompass: analysis of the consistency of the product implemented and fulfillment of initial requirements, the ergonomics of the product, level of achievement of the objectives.
- Further new developments: possible new developments and any changes to be made for a possible extension of the consultation service from the operational units involved during the experimental stage to other departments of the same hospital or, in the eventuality, other external hospitals.

The outcome measures to evaluate efficacy and efficiency of the web-platform developed for this purposes are:

- The satisfaction of specialists involved (measure of efficacy). This parameter will be evaluated through the analysis of the customer satisfaction form filled both by the ID specialists and by the hearth surgeons at the end of each consultation;
- The number of RIDC performed compared to historical data of bed-side consultation process (measure of efficacy);
- The number of bed-side consultancies needed for the insufficiency of web-based data (measure of efficiency);
- The time spared in staff movement avoiding (measure of efficiency). This measure will be evaluated simulating several distances between the ID specialist' hospital and the hospital which asks for the ID consultation.

Any consultation can be used as teaching material to analyze the diagnostic work-flow process, the choice of empirical treatment pending cultures, the evaluation of the susceptibility test performed on isolated microorganisms and the following guided treatment, the timing of dose-delivery methods for antibiotic / antifungal / antiviral drugs, for the monitoring of treatment outcome, for the side and untoward effects, for the dose adjustments, etc.

2.3 Technological Key Elements

The originality and the strength of this prospective work is its building process. This is based on the interaction of technicians and physicians who give their contribution from different points of view to identify the most appropriate tool able to reach these objectives.

Many Italian hospitals are equipped (and many others are going to equip) with healthcare information systems oriented to the management of clinical events.

In particular, in the Lombardy Region, various Hospital Information Systems (HIS) are evolving according to the guidelines of SISS (acronym of "Sistema Informativo Socio Sanitario", the Lombardy Healthcare Information System) (Barbarito, 2012).

SISS can be defined as the set of IT applications and infrastructures in the Lombardy Region (IT systems for pharmacies, doctors, hospitals, Lombardy Region offices, etc.) that contribute to the provision of healthcare services within the Region.

SISS today consists of a number of systems that are gradually evolving, according to a specific IT strategy in e-health matters, in order to put into practice more widespread and pervasive Information and Communication Technologies (ICT) for innovation purposes.

In addition to these considerations, the ID department protagonist of this paper wanted to add more value to the EHR currently in use and enforced its functionalities.

This platform, already capable of managing the entire care process in a paperless way and of improving the clinical risk management procedures compliantly (to Joint Commission International standards and Italian Legislation), was integrated with further features that could allow the exchange of medical and scientific expertise, based on real clinical cases, with an eye to provide continuing online education to physicians.

From a technological point of view, a careful examination of various type of healthcare, scientific and documentary aspects has led to the implementation of a real clinical tool accessible via the web on any terminal or device with a browser (PC, Tablet-PC, etc.). Connectivity is achieved regardless of the operating system and functionality enables doctors and nurses to perform all the tasks related to patients care.

To obtain a real paperless solution each clinical task inserted in the system is digitally signed with smartcard (as required from the Italian law) and this permits the definitive replacement of inpatient and outpatient paper medical records electronically (Lisi A, 2010; Rossi L, 2006).

The operational workflow commences with the operator who accesses the portal by typing a URL, like an ordinary website, but conveniently protected with personal username and password (fig. 1).

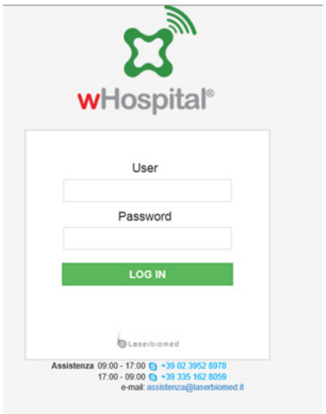

Figure 1: Access to the portal for remote ID consultation.

Each user that has been securely enabled and assigned to one or more operational units, may log into the portal and pass a request for a new RIDC to another unit or department.

Once the patient is correctly identified, users can proceed and fill out a consultation request (fig. 2) form which requires some mandatory data such as; hospital, operational units, specialists needed, for the remote clinical evaluation, priority (non-urgent, moderately urgent, absolutely urgent, …) and main reason for the RIDC.

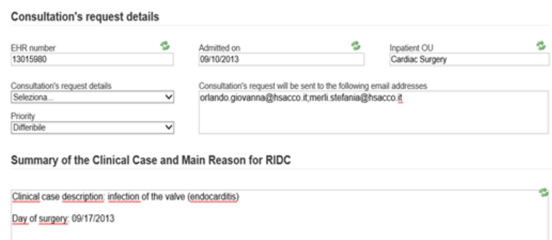

Figure 2: Form for the consultation request for the patient "Mario Rossi".

Due to the configurability of the platform, information required in the request form is still modifiable according to need.

Items available for the corresponding pop-up menu can be customized pursuant to the needs that may possibly arise during the utilization of the system.

Physicians can accede to both the list of requests of consultations already sent to other operational units and to the list of requests coming from other units.

A series of filters related to the time period in which they look for these requests and their status of implementation (e.g. visits scheduled – executed - in execution - canceled) are always at the users' disposal.

2.3.1 Architecture of the EHR

The EHR architecture, configured according to the requirements that emerged in the initial phase of analysis, provided for the introduction of three sections (request for consultation, consultation assessment, module for documents uploading), each containing some specific clinical forms.

In the first section "request for consultation" there is a consultation request form with basic information such as the reason for the request, the reason for patient's admission and so on.

The EHR platform includes a framework where it is possible to create in an easy way new forms (or modify forms already existing) with structured data by linking certain values of particular clinical interest to specific functions.

In addition to the information inserted in the clinical form available, the EHR portal enables the upload of other paper-based data after acquisition through scanner (e.g. pdf and word documents, jpeg files, …) and the use of the digital signature procedure part of the system as previously described.

Therefore, users may load any external documentation in order to proceed to a more comprehensive request/response of consultation.

When applying for a consultation an email notification is sent to the addressee delivering the essential information about the request, such as soliciting physician, his operational unit and priority of the request.

The doctor addressed with the ID consultation has access to the form filled out by the colleague (in the pilot phase, a heart surgeon) and examines the documentation loaded for the clinical case.

In this way, the doctor is able to provide a first in-depth analysis of radiological images, ECG, photographs of skin lesions, laboratory tests and other documents as well as the clinical history of the patient at issue.

After the evaluation of the documentation is terminated, the consultant (in the pilot phase, the ID specialist) can respond by filling out a special form that will include the ID opinion.

The third section "consult assessment" consists of two forms for the assessment of the completeness of the case presentation. These forms have been designed to measure the degree of satisfaction of the addressed operator with respect to the data provided by the sender.

Consequently, the ID specialist has the opportunity to assess the completeness of the description of the clinical case while the cardiac surgeon evaluates the response returned from the ID specialist.

The features developed for the part of the web platform related to the feedbacks are of great importance from the educational point of view since they allow the examination and realization of how a particular clinical aspect has been addressed by a senior specialist. This may also represent an additional means of professional development for younger colleagues.

The structure of the patient's "clinical dossier" allows operators to get a simpler guided navigation, increasing flexibility, modularity and ease of use of information made available.

3 PRELIMINARY RESULTS

In 12 months, from the beginning of the simulation tests of the customized Electronic Health Record (EHR), 18 simulation tests, 19 Remote Infectious Diseases Consultations (RIDC) by Infectious Diseases Specialists of the I Division of the L. Sacco University Hospital, Milan – Italy have been performed with 52 accesses to the EHR of patients admitted in the Cardiac Surgery and Post Operative Intensive Care Unit of the hospital.

The mean time ranging from the web-call and the RIDC was 2 hours (range 2 - 960 minutes). A comparison with the time occurred for the bed-side consult in the same unit is ongoing: the 94 bed-side consultations performed between Jun 2013 - Jan 2014 were delivered after a mean of 8.3 hours (range 30 – 1440 minutes). The real Δ-time from the call and the consultation delivery will be evaluated when the system will be tested in a really remote setting.

Among the questionnaires made to evaluate the platform, the major limit arisen of the system efficacy was the time spent for the completion of data required to fully-describe the clinical case and to collect requisite data required to facilitate the diagnostic and therapeutic process. After this first phase, several structural adjustment are currently under revision.

In Table 1 are reported the topics stored since now as a clinical database which can be used for e-learning and training of ID students. All the cases stored represent very important and up-to-date issues for the management of severe infectious diseases in high risk patients.

Table 1: Clinical cases stored for e-learning and training of ID students.

Clinical case	N	%
Sepsis	5	26.3
Ventilator (VAP) or healthcare associated (HCAP) pneumonia	4	21.0
Native (NVE) or Prosthetic (PVE) valve endocarditis	2	10.5
Surgical Site Infection (SSI)	2	10.5
Chronic liver disease	1	5.3
Clostridium difficilis colitis	1	5.3
Other	4	21.1
Total	19	100

4 CONCLUSIONS

This pilot project, currently involving two operational units within the same hospital, is proving to be an interesting and intelligent learning experience for many specialists with different levels of expertise. The project can easily be extended, not only to other departments of the hospital, but also to other hospitals in the area interested in the care of IDs and nosocomial infections.

Among the benefits gained we are proud to emphasize the implementation of additional training content related to ID studies accessible with simplicity and immediacy, and especially the possibility of reducing now and again the logistical and time-management training costs of new specialists (e.g. avoiding transfers for "face to face" traditional training, giving the possibility to study new clinical cases also in non-working hours from home, etc.).

The project could potentially modify substantially the specialists consultation process which is actually based on the movement of specialized personnel. In perspective it is important to stress the possibility of extending access to the portal to a larger number of users and operators nation-wide with the idea of establishing networks of ID specialists consultations not only at regional level.

So far, the initial goal of the project, which is to develop a computer technology that would enable the structuring of case studies by means of innovative technology-based learning strategies localized in a real context of patient care, can be said to be fully achieved.

This is mainly because users' have taken advantage of data inserted into the system from the consultations' part of a real EHR that is open to support distance education and exchange of information, opinions and feedbacks among a considerable number of professionals.

ACKNOWLEDGEMENTS

This project was funded by Italian Ministry of Health (project GR-2009-1568943 CUP E41J110001).

We want to thank every single ID specialist for the patience, diligence and commitment demonstrated in order to learn how to use this new information technology platform.

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CALL for Open Experiments

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Keywords: Computer-assisted Language Learning, Intelligent Systems, Virtual Labs.

Abstract: In this paper, we briefly describe the limitations of present CALL systems, caused both by technological factors and by the limited agenda of CALL developers, whose design goals tend not to result in software tools for practical everyday language learning activities. We also note the lack of creative new ways of using computers in language education and a gradual shift towards traditional teaching and learning practices, enhanced with common computer technologies such as multimedia content delivery systems and social media. However, computers can provide more options for interactive learning, as shown by the emergence of virtual labs or virtual sandboxes that support and encourage open experimentation. Such systems are well known in natural sciences, but still have had little impact on the world of CALL software. We believe that the same "free experimentation" approach used in natural sciences can be applied in CALL, and should have a positive impact on the quality of learning, being consistent with constructivist perspectives on language education. In the present paper, we briefly introduce our work-in-progress to develop a system that supports open experiments with words and phrases.

1 INTRODUCTION

When computers became commodities, terms like "computer-assisted *X*" lost some significant part of their initial meaning. We do not refer to "ballpoint pen-assisted writing" or "car-assisted traveling", and yet "computer-assisted language learning," or CALL, is still in common use. In regard to CALL, we should probably imagine dedicated educational systems that somehow "assist" learning in a nontrivial technologically-driven way, but ironically common definitions of CALL simply refer to the use of computers in language learning activities (Levy, 1997). In particular, using an electronic dictionary or watching a foreign-language clip on YouTube are perfect examples of "computer-assisted language learning", though neither an electronic dictionary nor a video-sharing website were explicitly designed to support language learning.

Furthermore, it also seems to us that such general-purpose software is the most widely used and most helpful for the learners. By contrast, there are hundreds if not thousands of available dedicated software packages for language acquisition, but strikingly they are rarely mentioned in numerous "language learning tips" found online (Leick, 2013; Hessian, 2012).

In general, computer technology holds a firm position as a helper within traditional teaching and learning practices. We learn language by listening, speaking, reading, writing, and doing (established) exercises, and computers provide unprecedented support and convenience in these activities. However, overall they still fail to provide fundamentally new teaching and learning practices, unavailable in traditional paper-and-pencil scenarios.

Even dedicated CALL systems (such as the ones developed by companies like Eurotalk, Berlitz or Rosetta Stone) are typically designed as integrated packages of traditional learning materials — audio/video clips, pictures, texts, exercises, and vocabularies. In other words, current CALL systems can be considered primarily as highly usable and modernized versions of traditional "book + tape" self-learning courses. The survey conducted by Hubbard in 2002 revealed that even the CALL experts are not convinced about the effectiveness of educational software. Hubbard notes: "*...it is interesting that questions of effectiveness still tend to dominate. In fact, the basic questions of "Is CALL effective?" and "Is it more effective than alternatives?" remain popular even among those*

* Supported by JSPS KAKENHI Grant #25330410

who have been centrally involved in the field for an extended period of time.” (Hubbard, 2002).

We suggest that the reasons are both technological and psychological: many computer technologies relevant to language learning are indeed not mature enough to be used in practical CALL systems, and our traditional learning habits make it hard to design fundamentally new systems that would utilize the full power of today's computing hardware.

2 CALL MEETS TECHNOLOGICAL LIMITS

A number of language learning software insturuments can do more than merely support traditional learning activities, but their overall capabilities are still limited (Hubbard, 2009).

We can add that research efforts in this area are limited, too. For example, Volodina et al. observe that only three natural language processing-backed CALL systems have come into everyday classroom use (Volodina et al., 2012). Furthermore, as noted in (Amaral et al., 2011), “*the development of systems using NLP technology is not on the agenda of most CALL experts, and interdisciplinary research projects integrating computational linguists and foreign language teachers remain very rare*”.

Possibly, the only “intelligent” technology that has made its way into some retail CALL systems is automated speech analysis, which is used to evaluate the quality of student pronunciation. Such an instrument is implemented, e.g., in commercial Rosetta Stone software, but its resulting quality is sometimes criticized (Santos, 2011).

We have to state that future development of ICALL systems crucially depends on significant achievements in the underlying technologies. Language learning is a sensitive area, where misleading computer-generated feedback may harm students. So it is impossible to expect any rise of intelligent CALL systems before the related natural language processing technologies improve vastly.

3 THE PROBLEM OF LIMITED AGENDA

However, computers can significantly improve learner experience even without advanced AI technologies, and provide “killer features” that are inherently computer-backed and cannot be easily reproduced in traditional environments. A good example of such an “inherently computer” system is any electronic dictionary, as it can implement a number of unique capabilities that create new use cases:

- approximate word search;
- partial search (find a word fragment);
- full-text search (find example phrases);
- arbitrary word form search;
- handwritten characters input.

Surprisingly, most popular dictionaries implement only a fraction of this list. It should be noted that none of the mentioned functions require the use of any immature research-stage technologies, and can be implemented with established methods.

Another example is spaced repetition-based flashcards software such as Anki (Elmes, 2013) or SuperMemo (Wozniak, 2013). While in spaced repetition can be exercised without a computer, it is a laborious process, hardly tolerable for most learners. So despite being relatively simple, these tools are efficient learning aids (as spaced repetition practices are proven to be effective (Caple, 1996)), and yet seldom mentioned in CALL-related papers.

So, it seems that CALL experts have not paid much attention to the development of everyday language learning tools. This situation is unfortunate, as it is inconsistent with the current trend of seamless integration of technologies into existing learning activities and with declarations of a preference for a student-centered approach that should presumably allow learners to follow their preferred learning styles or at least to ensure higher flexibility of the learning process.

4 VIRTUAL SANDBOXES

Such a technology-backed, student-centered approach is already implemented in a number of educational systems for the disciplines such as physics, chemistry, and computer science. Notably, there are sandbox-like environments (or “virtual labs”) that do not restrict their users and do support open experimentation.

For example, Open Source Physics project (Christian et al., 2013) collects together a vast amount of interactive physical simulations with user-adjustable parameters. The 2D physics sandbox Algodoo is positioned by its authors as *“the perfect tool for learning, exploring, experimenting and laborating* [sic] *with real physics”* (Algoryx, 2013). The ChemCollective collection (Yaron et al., 2013) includes a number of ready setups for chemical experiments as well as a virtual lab for open exploration. The JFLAP environment (Rodger, 2013) allows students to create, analyze and test finite-state machines — the devices that constitute the basis of computer science.

We consider such systems as great examples of well-grounded uses of computer technology in education. Virtual labs provide safe and controlled environments in which students can test their ideas, and in this sense they can be likened to flight simulation software, used to train pilots: the students perform predefined training routines, but also can experience the outcome of any arbitrary maneuver. Furthermore, virtual labs contribute to the modeling of the problem domain in the learner's mind, and thus are consistent with constructivist views on educational process.

It is interesting to note that from the technological point of view, virtual labs are not necessarily complex systems. The possibility of open experimentation outweighs many technical limitations and constraints.

Unfortunately, environments for open experiments are barely provided by the existing CALL systems. This perhaps can be attributed to the unclarity of the notion of an "experiment" in language learning. It is evident, however, that a large portion of active language learning is related to the process of combining words and phrases into meaningful sentences, and the analysis of the subsequent feedback. We learn a language both by comprehending other people's speech and writing, and by creating our own phrases that are to be tested for admissibility by our interlocutors.

Within such a concept of experiments, even a feature-rich electronic dictionary can be a powerful experimental tool in the hands of an avid learner. Indeed, with full-text search it is possible to check actual word use, test the correctness of certain word combinations, the compatibility of certain prefixes with certain stems, etc.

The ways in which students could do "experiments with the language" are still to be identified. Here we can only quickly introduce our own work-in-progress system that is intended to help language learners master basic grammatical rules.

5 TOWARDS WORDBRICKS

One of the most basic aims of language learning is to train the ability to formulate grammatically correct sentences with known words. Unfortunately, traditional exercises lack active feedback mechanisms: learners are unable to "play" with language constructions to find out which word combinations are admissible and which are not. The best (and maybe the only) way to train active writing skills is to *write* (essays, letters…), and to get the writings checked by the instructor. Some intelligent CALL systems, such as Robo-Sensei (Nagata, 2009), can assess students' writings by using natural language processing technologies, but the success of these instruments is limited.

We suggest that active skills of sentence composition can be improved by forming a consistent *model of language* in the learner's mind. Metaphorically speaking, the difference between a "consistent model" and a set of declarative grammar rules in this context is the same as the difference between a Lego construction kit and a lengthy manual describing which Lego bricks can be connected and in which ways. A child does not need manuals to play Lego: the rules of brick linkage can be easily inferred from brick shapes and with some trial-and-error process. Unfortunately, there is no such way to easily check whether it is correct to combine certain words in a sentence.

The idea of modeling syntactic rules with shaped bricks was implemented in the educational programming environment Scratch (Resnick et al., 2009). In Scratch, individual syntactic elements of a computer program are represented with shaped bricks that have to be combined to constitute a program (Figure 1a). While Scratch code may have logical errors, syntactically it is always correct, since it is impossible to combine mismatching bricks.

Scratch's graphical editor is not just a simpler way to write computer programs, helpful for the beginners. It can be treated as a *construal* (Gooding, 1990) that forms a model of a programming language in the learner's mind, though this aspect is not explicitly emphasized in Scratch.

In our research, we are working towards implementation of a similar scheme for natural language sentences. Undoubtedly, natural language grammar is much more complex and less formal than the syntax of any programming language. However, for the purposes of novice language learners, it is reasonable to teach restricted grammar (as it happens in traditional language teaching), which is technologically feasible.

Even in the case of Scratch, the design of brick linkage principles is not trivial. One important problem is to make sure that the links between the bricks reflect *actual* structure of the corresponding computer program. For example, a loop control

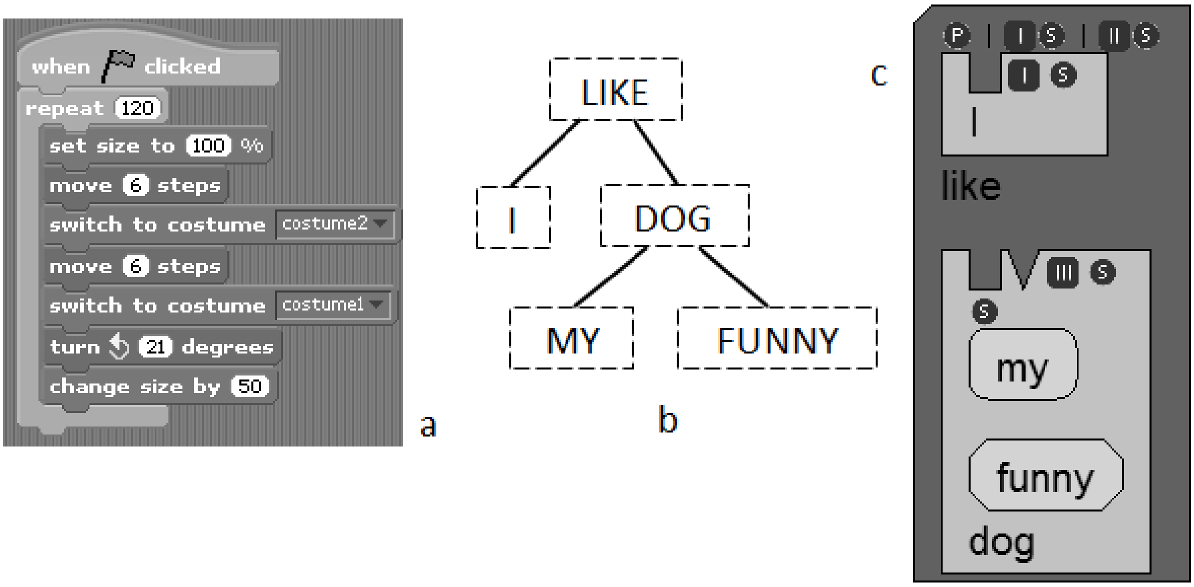

Figure 1: a) A fragment of Scratch program; b) Dependency tree of the phrase "I like my funny dog."; c) Dependency tree of the same phrase in the form of 2D puzzle.

structure can be represented with the separate "Begin Loop" and "End Loop" bricks that surround bricks that constitute the loop body; however, such a design would make a false impression that "Begin Loop" and "End Loop" are independent program elements. Instead, a loop in Scratch is represented with a single C-shaped brick that embraces the loop body.

It is much harder to identify a consistent set of rules that control such linking principles of a natural language-based system. However, they are actually considered in a number of linguistic theories. In particular, we base our rules on the principles of *dependency grammars* (Nivre, 2005). Existing guidelines, such as the Stanford Typed Dependencies Manual (Marneffe & Manning, 2008) describe in detail how the words in the given sentence should be linked to form a structure consistent with the ideology of dependency grammars. For example, a subject and an object should be directly connected to their head verb; an adjective should be directly connected to its head noun (Figure 1b).

The resulting structure of a sentence is represented with an *n*-ary tree. While this structure is linguistically correct (according to the theory of dependency grammars), it arguably might be difficult for learners to master it. Therefore, it is our challenge to represent such trees as two-dimensional brick puzzles. Furthermore, dependency grammars do not express word order, while it has to be reflected in the resulting brick structure (Figure 1c).

The proposed learning environment can be used in different scenarios, but we would emphasize again the possibility to perform open experiments. Learners will be able to test which word combinations are admissible and why.

We should also note that it is an open question whether language learners (at least in the early stages of learning) should study sentence structure. However, we believe that some gentle exposure is fruitful, especially for learning languages with rich morphology, where a single change in one word may trigger changes in several of its dependent words.

6 CONCLUSIONS

Computer technologies are widespread in modern language education. Some directions in CALL research, such as intelligent systems, have not yet been as fruitful as anticipated, while other developments, such as multimedia and networking capabilities, have surpassed our expectations.

It seems that the present agenda of CALL research is primarily focused on exploring recent technologies such as ubiquitous computing or Web 2.0. However, we see that even basic language learning tools, such as electronic dictionaries or flashcard software, would benefit from greater attention by CALL developers. Ubiquitous and mobile computing technologies stimulate learner's independence, but language learners still lack tools that support independent language exploration and make use of computing hardware not just as a platform for the delivery of multimedia data.

We would especially favor more developments in open experimentation language software. This direction has promising advancements in a variety of scientific fields, but not yet in CALL.

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An IEEE 1599 Framework to Play Music Intuitively
The Metapiano Case Study

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Keywords: Education, IEEE 1599, Music Meta-instruments.

Abstract: This work aims at proposing an innovative way to approach music education. The idea is coupling the power of IEEE 1599, an XML-based international standard for music description, to the concept of music meta-instruments, namely new interfaces conceived for a simplified interaction with music contents. The proposed framework will provide a tool for music practice, powered by the multiple and heterogeneous contents contained in an IEEE 1599 document. A case study based on Jean Haury's metapiano will be presented.

1 INTRODUCTION

Music education is evolving in several directions using electronic, information, and communication as enabling technologies to make the teaching process more effective and to enhance the human ability to learn. Computer-assisted musical learning has several approaches. Musical games, a subset of computer games, are finalized to enable kids to interact with music intuitively, stimulating different types of intelligence, such as the instinctive, intuitive, and sensory-motor one (Wechsler, 1975). The application of computer games to music education has been discussed in a number of scientific works - see e.g. (Denis and Jouvelot, 2005) - and exploited in many experiments - see e.g. (Kim et al., 2008).

In this paper we want to introduce a new paradigm for music education, based on the concept of meta-instrument. A *musical meta-instrument* (Miranda and Wanderley, 2006; Malcangi and Castellotti, 2013) can be either a virtualization of an existing instrument or a brand new one; in any case, it is conceived to move the sound generation and texture capabilities into the instrument itself, and to leave sequencing and timing under the performer's control. In this sense, it aims at being closer to the natural and intuitive ability of the performer, in order to enable him/her to play music without a specific technical skill. In our opinion this new learning paradigm is extremely innovative since it could remove any starting barrier between the person and the instrument.

The behaviour of a meta-instrument somehow resembles an orchestra conducted by a director. In fact such a tool requires a score in input but it has no knowledge about timing and interpretation in itself: it acts like an orchestra player waiting for conductor's instructions. The gestures required to produce sounds are demanded to a human player, who - freed by a number of technical constraints - should be able to perform music in a more straightforward way.

The activity of playing a meta-instrument, when instanced in an appropriate context, can become a kind of music game. It is worth citing the case study of the popular console video game *Guitar Hero* (Miller, 2009), which documents the changing nature of amateur musicianship in an increasingly technological world. The framework we will propose in the following is not oriented to pure entertainment, rather to edutainment. It aims at constituting an entry point to music learning, also for handicapped students who have physical, mental or health impairments.

In our approach, two key paradigms of music - namely the writing-oriented and the performance-oriented paradigms - are mixed for educational purposes. This experiment has already been successfully conducted in other contexts, for instance in electroacoustic music composition, as reported in (Desainte-Catherine et al., 2013).

In order to transform the concept of musical meta-instrument into a real tool to play intuitively, we propose a framework that embeds meta-instrument notation in the IEEE 1599 format. The latter is an XML-based international standard for the representation of music in all its aspects. Section 2 will present the key concept of IEEE 1599, whereas Section 3 will provide details on the proposed solution.

Finally, Section 4 will introduce a clarifying example based on the experience of Jean Haury's metapiano. This already existing tool has been adopted in our case study to test the effectiveness of a "meta-instrumental" approach to music education.

2 AN OVERVIEW OF THE IEEE 1599 FORMAT

IEEE 1599 is a standard internationally recognized by the IEEE, sponsored by the Computer Society Standards Activity Board and designed by the Technical Committee on Computer Generated Music. IEEE 1599 adopts XML (eXtensible Markup Language) in order to describe a music piece in all its aspects (Baggi and Haus, 2009).

The innovative contribution of the format is providing a comprehensive description of music and music-related materials within a unique framework. The symbolic score - intended here as a sequence of music symbols - is only one of the many descriptions that can be provided for a piece. For instance, all the graphical and audio instances (scores and performances) available for a given music composition are further descriptions, as well as text elements (e.g. catalogue metadata, lyrics, etc.), still images (e.g. photos, playbills, etc.), and moving images (e.g. video clips, movies with a soundtrack, etc.).

Comprehensiveness in music description is realized in IEEE 1599 through a multi-layer environment. The XML format provides a set of rules to create strongly structured documents. IEEE 1599 implements this characteristic by arranging music and music-related contents within six layers:

- *General* - music-related metadata, i.e. catalogue information about the piece;
- *Logic* - the logical description of score in terms of symbols;
- *Structural* - identification of music objects and their mutual relationships;
- *Notational* - graphical representations of the score;
- *Performance* - computer-based descriptions and executions of music according to performance languages, such as MIDI or MPEG4;
- *Audio* - digital or digitized recordings of the piece.

Music events are univocally identified in the encoding, so that they can be described in different layers (e.g. the graphical aspect of a chord and its audio performance), and multiple times within a single layer (e.g. many different music performances of the same event). Consequently, in the multi-layer environment provided by IEEE 1599, one recognizes two synchronization modes:

1. *Inter-layer synchronization*, which takes place among contents described in different layers. Different layers store - by definition - heterogeneous information, to allow the enjoyment of heterogeneous music contents simultaneously, in a synchronized way. Applications involving multimedia and multi-modal fruition, such as score following, karaoke, didactic products, and multimedia presentations, can be realized thanks to this kind of synchronization;
2. *Intra-layer synchronization*, which takes place among the contents of a single layer. Each layer contains - by definition - homogeneous information. Thanks to this feature, one can jump from an instance to another instance of the same type in real time, without losing synchronization.

Coupling the aforementioned kinds of synchronization, it is possible to design and implement advanced frameworks for music. For further details about the format, please refer either to the official IEEE documentation or to a recent book covering many specific aspects of the standard (Baggi and Haus, 2013).

In this context, the most relevant aspect is the possibility to integrate and synchronize within an IEEE 1599 document many heterogeneous kinds of description, including any form of meta-instrument notation. This matter will be discussed in depth in the next section.

3 THE PROPOSED FRAMEWORK

In our approach, two activities can be clearly distinguished: *music encoding* and *music performance*. Usually they are asynchronous, since the former can be completed before the performance, and often this is even required by a number of technical issues. In fact, for our goals music encoding implies the production of a "rich" IEEE 1599 document, namely a single XML file containing both the spine and the meta-instrument notation, mutually linked. Encoding music in a proper way during a live performance is a

```
1 [] 1 63 [< 4 70 [< 3 75 [< 2 79
2 [>  4 70 [> 3 75 [> 2 79 [] 1 75
3 [] 1 74 [< 4 67 [< 3 70 [< 2 79
4 [] 1 70
5 [] 1 72
...
```

Figure 1: A short example of plain-text notation for J. Haury's metapiano. The score contains voice, pitch and velocity encoding, together with basic information on articulations.

hard task, even if theoretically feasible (Baldan et al., 2009).

Needless to say, an IEEE 1599 document can contain much more, as explained in Section 2. For instance, it could host a number of pre-recorded audio tracks referring to other performances of the piece, or conceived as a background for the current performance.[1] Similarly, the *Notational* layer could host evocative graphics together with a traditional score version in common Western notation.

A number of IEEE 1599 applications oriented to music education has been treated in (Baratè et al., 2009) and (Baratè and Ludovico, 2012). In this context, the novelty is the presence of meta-instrument notation. Usually it contains basic symbolic information (i.e. notes, rests, a few articulation signs, etc.), namely the input required by the meta-instrument parser. A simple example is the notation for the metapiano by Jean Haury, illustrated in Figure 1. It is worth underlining that the information contained in a meta-instrument score is potentially redundant with the contents of the *Logic* layer, and actually the knowledge of encoding rules makes an automatic conversion possible between formats.

Moreover, software tools and plug-ins have been developed to compile the *Logic* layer starting from commonly adopted formats (e.g. MusicXML and MIDI) as well as score editing software (e.g. MuseScore, MakeMusic Finale® and Sibelius®). Similarly, computer applications could be implemented for *ad hoc* meta-instrument scores, too.

IEEE 1599 provides richness in music description, including multiple audio, video and score digital objects. Since the format supports any representation of score symbols, also new notation for music meta-instruments can be embedded and synchronized with all the other contents.

[1]Please note that in this case timing information would be implicitly provided to the human player. Such a result could be either desirable, e.g. to teach students how to go in time with the music, or unwanted, e.g. to make children express themselves during Music Therapy sessions.

After producing the IEEE 1599 document, the second phase - i.e. music performance - is enabled to start. Before the design of this framework, two totally independent concepts were available:

- An *IEEE 1599 viewer*, namely an environment oriented to a multi-layer and synchronized musical experience. This software is able to present simultaneously information contents from multiple layers, allowing the user to enjoy them together and to choose the material to bring to front. The user is active in the choice of current materials (scores, audio tracks, video clips, etc.), and he/she can use standard navigation controls (start, stop, pause, change current position); however, from the performance point of view, the user can only experience already prepared materials.
- A meta-instrument parser, where a symbolic score is loaded and the user can interact through the interface of the musical instrument. The parser is not standard, since it is customized for the peculiar meta-instrument. Besides, it usually gets input only from the external controller and from a digital score representation. Consequently, other interactions with related materials is demanded to *a posteriori* processing of its output, which limits the expressive possibilities of the framework.

These two environments could be (and actually have been) implemented under different HW/SW architectures, and implementation details are not relevant for our proposal. For instance, IEEE 1599 players have been developed for multi-platform off-line fruition as well as embedded in Web portals. Similarly, there are some meta-instruments entirely implemented via software and others based on the communication between Arduino and Max/Msp environment. An example of the latter category will be provided in Section 4. Our idea is creating a unique framework where the two contributions can be mixed and integrated, in order to take advantage by both the approaches.

As regards the music meta-instrument, it can be any hardware or software device capable of sending computer-interpretable messages: MIDI controllers, external peripherals such as computer keyboards, graphical interfaces, and so on.

The function of the parser is interpreting both the IEEE 1599 and the controller input, producing a sequence of commands to drive the player. One of the key roles is disambiguating synchronization. As mentioned before, most contents in an IEEE 1599 document have intrinsic timing information, such as all audio and video tracks. On the contrary, in this context metronome is provided by the human player, so

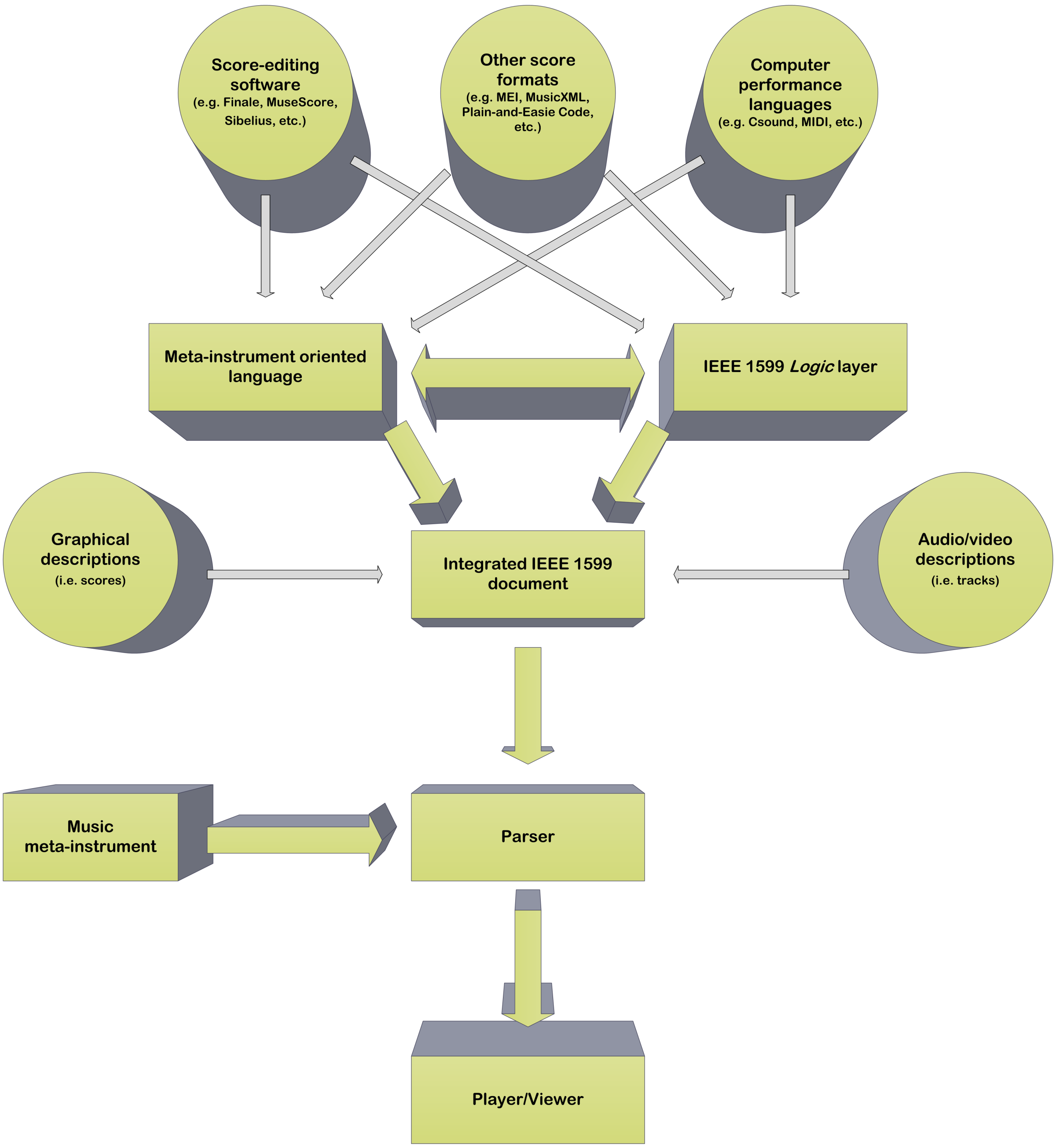

Figure 2: Process flow chart of the proposed framework.

the parser has to match human gesture with meta-instrument notation, and other contents must be consequently timed.

Figure 2 illustrates the proposed framework. The upper half corresponds to music encoding, whereas the lower half is about music performance.

4 CASE STUDY: THE METAPIANO

The metapiano is a musical meta-instrument made of only nine piano keys (Haury, 2013). It can be played with a few fingers, or even with one finger, as shown in Figure 3. The metapiano notation stores the notes to be performed by the musician. In practice, the music is analysed in terms of its melodic, harmonic, and contrapuntal relations. Only notes' pitches and their relations are codified and stored digitally, according to *pianotechnie* rules (Haury, 1987).

This musical structure can produce music and sound by playing the metapiano's limited number of keys. The musician can instantly interpret music with his/her own style by applying his/her rhythm, tempo, articulation, accent, dynamic and agogic phrasing.

In this kind of meta-instrument pitch information is received from the score, and consequently reconstructed at parser level. The 9-key interface is provided only to allow more effective gestures. For instance, quick sequences of notes are easier to be obtained using many fingers, independently from the melodic contour. Similarly, a *legato* effect can be obtained only using at least two keys.

Experiments have shown that such an interface is extremely intuitive for complete beginners and inexpert players, who are not used to associate keys to sounds (Haury and Schmutz, 2006). On the contrary, for skilled piano players this abstraction is harder to be managed. However, the latter category is not the typical recipient of our initiative.

In order to apply the IEEE 1599-based framework to the metapiano case, a meta-instrument oriented language layer has been designed. This language is based on the syntactic and semantic encoding defined by Jean Haury. Starting from an XML encoding of the score, an integrated IEEE 1599 document is generated to feed the parser controlled by a musical meta-instrument interface. In this way, a 3-level hierarchy of music representation has been realized:

1. A low-complexity encoding for complete beginners, namely people unable to read music scores and to play any music instrument;
2. A medium-complexity encoding for learners, namely people who can read scores but with no instrumental skill;
3. Finally, a high-level encoding for musicians, namely people interested in improving their music abilities and experiencing new kinds of music interfaces.

Our approach can be easily extended to any other music meta-instrument, thanks to the extensibility of IEEE 1599 format.

5 CONCLUSIONS AND FUTURE WORK

In this work we have introduced at first the key features of IEEE 1599. Such a format allows a comprehensive description of music in all its facets, supporting multiple media encodings and keeping digital objects synchronized. Even if commonly adopted for education purposes, this format was never used before for music performance. The innovative idea is introducing a special controller acting as a music meta-instrument and designing a framework to integrate such a tool and the related notation with an IEEE 1599 parser/player.

Figure 3: Jean Haury playing F. Chopin's *Étude Op. 10 No. 4* on his 9-key metapiano.

Future work will concentrate on a re-engineered implementation of the framework, extensive tests conducted on impaired children and piano beginners, and the extension to meta-instruments other than Haury's metapiano.

ACKNOWLEDGEMENTS

The authors gratefully wish to acknowledge the researchers who contributed to this work. In particular, we want to thank for their support: Jean Haury, the inventor of the metapiano, Pierre Castellotti, an expert in the field of meta-instruments and musician-to-machine interfaces, and Stefano Bruni, who implemented an automatic generator and translator of metapiano notation.

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Teaching Mathematics in Online Courses
An Interactive Feedback and Assessment Tool

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Keywords: Online Courses, Mathematics, Assessment, Grading, Teaching, Tutoring.

Abstract: Online courses often require students to work self-dependently using books or video material. For abstract subjects such as mathematics this is particularly challenging. To improve student motivation and learning results, we propose an interactive feedback and assessment tool tailored to math exercises. Our system is able to process and analyze mathematical expressions using an underlying computer algebra system. It allows teachers to create exercises with a much wider range of question types as it is possible with today's learning management systems, which are mostly restricted to multiple choice questions. We can provide automatic individual feedback to students for almost any kind of mathematical exercise. Thus, making it easier for students to practice and study math in a self-dependent manner.

1 INTRODUCTION

Mathematics is the foundation of every engineering discipline. That is why teachers want students to reach a certain level of mathematical understanding. Meaning, that they should be able to apply learned techniques to new problems or even real world problems.

There is a consensus among teachers, that in order to master mathematical problem solving, students need to practice.They need to practice calculation methods e.g. how to compute the derivative for a certain type of function. And they need multiple examples to internalize the underlying ideas and to be able to generalize a technique to other tasks or settings.

In on-campus university classes students try to solve exercise problems and get feedback and assistance from their teachers or teaching assistants. Providing adequate feedback is one of the most important steps in the learning process. Without it, students often internalize incorrect rules or develop incorrect notions of mathematical problems and methods.

This feedback is ideally immediate or at least provided in a timely manner. Students need to be encouraged with positive feedback, if they solved a problem correctly. And they need to be made aware of mistakes as soon as possible. Note that this does not necessarily mean that step by step instructions are provided for each exercise. The teacher should be able to control the complexity of the exercises and the granularity of feedback to foster deep learning without frustrating the students.

For online courses this poses a particular challenge. On the one hand, communication between the teacher and students is still and always will be more difficult than in a face-to-face conversation (even though virtual classroom software is improving). On the other hand, the communication is, to greater extent, asynchronous.

Online courses are often taught through a series of videos combined with a discussion forum. Feedback to student questions is therefore typically delayed by hours or days. Live virtual classroom sessions typically only take place at the beginning or the end of larger learning units. Finally, with the advent of Massive Open Online Courses (MOOC) the teacher to student ratio makes individual feedback a challenge.

Without appropriate communication and feedback many students fail to achieve the required skills. In fact, the success rate for online courses is in most cases considerably below success rates of on-campus courses with a comparable student body. In (Collins, 2013) and (Thrun, 2013) the difference in success rate is as large 40% for an online course compared to the respective on-campus class in spring 2013.

In order to improve teaching of mathematical problem solving skills in online courses, we believe it is necessary to provide meaningful, individual feedback to every student, no matter whether there are 30 or 30000 students in a class. Learning management software e.g. (Moodle, 2013; OLAT, 2013) provides interactive (self-)tests, which allow students to practice and evaluate their skills. Thus, obtaining feedback on their learning progress. Unfortunately, giving automatic feedback for mathematical exercises is difficult. Responses may not only involve numeric values, but expressions may also include functions or mathematical sets which have many equivalent representations (e.g. $x(x+1)$ is equivalent to x^2+x). These mathematic expressions cannot be handled properly by state-of-the-art learning management systems.

For a meaningful feedback an interactive learning tool needs to better "understand" these mathematical expressions. As a first step in this direction we therefore propose an automatic feedback and evaluation system tailored to mathematical exercises. Our system leverages existing computer algebra software in order to evaluate student responses and to provide immediate individual feedback. It allows teachers to easily create custom content with the granularity of feedback of their choice.

With the automatic feedback functionality turned off, the system can also be used for efficient assessment and grading of large numbers of students.

2 ELECTRONIC SUPPORT FOR MATH TEACHING

In abstract subjects such as mathematics feedback plays an important role in the learning process. While self-studying from a book or video is important, students require much more support compared to facts-based subjects (e.g. history).

Traditionally, this support is to a large extent provided through face-to-face communication with teachers, teaching assistants or fellow students. When teaching online, we need to replace this valuable form of feedback using different means.

2.1 Virtual Classrooms

Virtual classroom software has gained widespread acceptance in recent years. Universities use commercial services like Adobe Connect or Google Helpouts [1] for live sessions between students and teachers. Virtual classroom software provides real-time audio and video communication. With the included whiteboard and screen sharing capabilities this setup can mimic the lecture style of large on-campus lectures. That is, a professor is explaining and students are listening.

[1] http://www.adobe.com/products/adobeconnect.html, http://helpouts.google.com

Student questions in these virtual classrooms are often tedious due to organizational issues (who is allowed to talk at which point?) and technical problems (microphone setup, network delays etc.). More over, the software or network often only allows for a limited number of participants. When groups are small, virtual classroom can, however, be a decent tool to provide feedback. Particularly, since touchscreens of today's notebooks and tablets make it easy to write mathematical equations and formulas.

2.2 Forums

Forums are another popular tool for online learning. Communication is asynchronous and thus does not provide immediate feedback. Students may ask a question and a member of the teaching staff responds later on. While in some cases this might result in students working harder to solve a problem all by themselves, the delayed feedback often also disrupts and postpones the learning process.

Forums require the teaching staff to spend a large amount of time formulating written answers to student questions, which is tedious and does not scale well to large amount of students.

2.3 Learning Management and Tutoring Systems

Existing learning management systems e.g. (Moodle, 2013; OLAT, 2013) and tutoring systems e.g. (Koedinger and Corbett, 2006; Melis and Siekmann, 2004) offer the functionality to create electronic exercise sheets. This allows students to practice and to obtain immediate feedback to their solutions. These systems may also display context-sensitive information, hints and instruction to guide students towards reasonable next steps.

LMS: Learning Management Systems. Generally, teachers are required to reformulate mathematical problems in a way, that is supported by the LMS. That is, in order to allow automatic feedback, exercises have been in the form of multiple choice or fixed answer questions.

Since these systems do not understand mathematical expressions and their equivalent representations it is impossible to use more complex expressions as a solution. Exercise questions allowing free-text fields are of course possible, but they require manual intervention, which leads to a delayed feedback.

Overall, current LMS limit the selection of possible exercises considerably, which is why most math teachers avoid using these systems.

ITS: Intelligent Tutoring Systems. In the context of this paper, we divide intelligent tutoring systems into two categories. One category of systems focuses on building student profiles while observing student performance in online tests and provides hints for the learner on its personal weaknesses and strengths (Schiaffino et al., 2008; Cheung et al., 2003),. These systems often build upon simple multiple choice and fixed answer questions and aggregate their results. They can tell a student e.g., that she/he has made many mistakes in the exercises on a certain topic. However, these systems cannot deal with mathematical expressions.

The other category focuses on domain specific problems. In the area of mathematics, there exist a number of these tutoring systems (Beal et al., 1998; Melis et al., 2009; Koedinger and Corbett, 2006). To our knowledge none of these systems leverage capabilities of symbolic mathematics software to support students. In fact, most of these systems focus on early high school level maths.

It is often hard for teachers to develop their own content for existing intelligent tutor systems. In fact, very few systems have detailed instructions on how to do this and in many cases programming skills are required. The Carnegie Cognitive Authoring Tools (Aleven et al., 2006) e.g. require authors to know Java or Adobe Flash. This is certainly one of the reasons, why the adoption of intelligent tutoring systems has been rather disappointing.

3 AN INTERACTIVE FEEDBACK AND ASSESSMENT TOOL

As pointed out in the sections above today's learning management systems are not prepared to deal with mathematical exercises.

The system proposed in this paper tries to combine interactive exercises with the capabilities of compute algebra systems. Our goal is to build a practice and assessment tool which is capable of "understanding" mathematical expressions and as a result give meaningful feedback and assistance to the students. Our system allows teachers to use a much wider range of exercise and question types as it is currently possible.

Contrary to many tutoring systems, we aim for math problems in general and do not want to restrict ourselves to a certain subdomain (e.g. dealing with fractions). That is, whether high school teachers want to design exercises to train the expansion of simple mathematical expressions or if university professors design exercises to solve differential equations, the capabilities of the underlying mathematical software should allow to provide meaningful feedback. More over, We want to make it simple for teachers to develop their own content without programming skills (see section 3.1).

3.1 Example Exercise

To get a better understanding of how the proposed system works, we present a short example exercise. We show how an exercise may be defined by the teacher and how the system reacts to user input. The technical details on how an appropriate user feedback is accomplished will be explained in subsequent sections.

Questions are displayed in a modern web-based user interface. Input fields allow students to enter their solutions and an appropriate feedback is returned once response has been submitted. In Figure 1 a student has provided an incorrect answer. Obviously he/she computed the derivative of numerator and denominator independently and the system displays the feedback directly below the input.

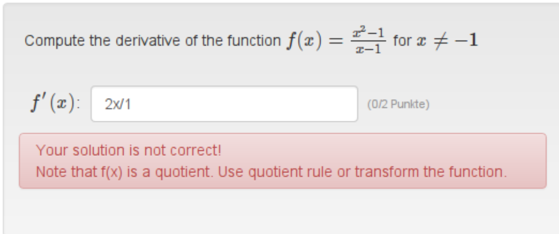

Figure 1: A hint is displayed if the provided solution is incorrect.

If a correct solution is entered, the input field turns green. Optionally, an exercise may yield points. Points may be used as a motivation or for grading purposes (see Figure 2).

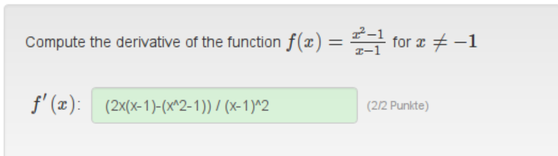

Figure 2: Correct solutions are marked green.

Finally, since the system recognizes mathematical equivalences, the user may input a different representation of the solution. In the above example the relatively complicated formula is, in fact, nothing else than the constant function 1 for values of $x \neq 1$ (see Figure 3).

Note that the system could also display additional feedback for correct but overly complicated solutions.

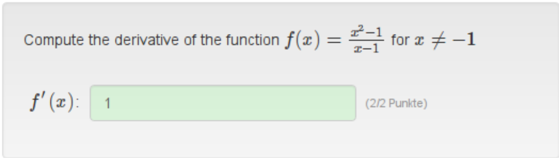

Figure 3: Equivalent solutions are recognized by the underlying symbolic math software.

Thus, hinting the student to a quicker way of solving the exercise.

Content Creation. Writing custom exercises is inspired by the syntax of markdown (Gruber, 2004), which has become quite popular in recent years. We use a relatively simple text format, with some control characters. The text format is later translated to HTML.

A new exercise is created by starting a line with three question marks followed by the title. Question text may contain LaTeX-style formulas (see below). LaTeX is still the most common format for defining math exercise sheets and teachers are familiar with it.

Since specifying a solution requires the definition of multiple values and properties, we opted for XML-syntax. A `field`-tag defines the expected solution type. In the example below this is a symbolic math value, i.e. a function, with the variable `x`. Embedded —answer—-tags define the behaviour depending on different user inputs. In the case below, the input of the value 1 results in returning points for the correct answer. The input $2x$ results in a customized feedback for the incorrect answer.

```
??? Derivatives
a) Compute the derivative of the function
$f(x)=\frac{x^2-1}{x-1}$ for $x\neq 1$
<field:symbolic var="x">
   <answer="1" points="2">
   <answer="2x" feedback="Note that f(x)
   is a quotient. Use quotient rule or
   transform the function.">
</field>
```

3.2 Solution Types of Mathematical Exercises

In order to allow teachers to use a wide range of different math exercises in an e-learning system, we need to be able to represent their respective solutions. In the following, we want to discuss the most common types of solutions for mathematical exercises. We will also point out the difficulties of representing and handling these solutions in an e-learning system.

Numbers. Numbers are probably the most common solution type for a math exercise. Even simple numbers have different ways of representation, which need special treatment in an e-learning system. The number 0.75 e.g. may be represented by the fraction $\frac{3}{4}$. If we want to allow students to enter either form, the e-learning system has to be aware of these representations. We also have to take care of irrational numbers like square roots or logarithms (e.g. $\sqrt{5}$).

One could argue that results could be restricted to rounded decimal numbers. Many teachers, however, prefer students to be able to solve exercises without a calculator. Solving a quadratic equation e.g. may easily lead to an irrational result, thus requiring a calculator to obtain a decimal representation.

Vectors and Matrices. For vector computations, we need to represent both matrices and vectors. In fact, since each entry in a vector or a matrix is a number, we also have to be aware of number representations as described above.

Intervals. Inequations often lead to number intervals as a solution. The inequation $x^2 - 4 < 0$ e.g. has all numbers between -2 and 2 as a solution. Intervals are essentially a pair of numbers with additional information of whether the interval is open or closed at the respective boundary.

Sets. Sets are unordered lists of numbers, which belong to a solution. The simplest example is the solution of a quadratic equation. The equation $x^2 - 1 = 0$ e.g. has the solutions -1 and 1.

Both sets and intervals can be combined using union, intersection or complement operators.

Functions. Exercises may also yield functions as a solution, e.g. when a derivative needs to be computed. There are many different possibilities to represent the same function, e.g. $x(x+1)$ is equivalent to x^2+x. An e-learning system needs symbolic calculation capabilities to deal with these.

Geometry and Proofs. Finally, some exercises require students to sketch a geometric object or graph. Others require them to proof a mathematical property. Both of these two types are out of scope of this paper.

4 SYSTEM IMPLEMENTATION

In the following we will discuss how user input may be verified leveraging the capabilities of existing math software. From the results obtained by this software, we generate a meaningful feedback for the students.

4.1 Computer Algebra Software

Mathematical software packages have become extremely capable. Tools like Maple or Matlab (Maplesoft, 2013; MathWorks, 2013) are widespread in academia. They are capable of manipulating mathematical expressions (e.g. solving an equation). While these are also great tools to be used independently of an e-learning system, they essentially require users to learn a programming language. In some cases this is more difficult for students than learning the mathematics itself.

We therefore hide this complexity from the user and do the manipulation of the user input transparently in the backend of our system.

4.2 "Understanding" Mathematical Expressions

Verification of user input depends on the solution type of an exercise. As we have seen in section 3.2 math exercises may have various different types of answers. In the following, we will show how to verify answers for these different types.

Numbers. While numbers have different representations, we can compare them by their values. In our implementation this is accomplished by subtracting the number provided by the student from the actual solution.

In Matlab this can be expressed with the following code, which is executed when students submit their results.

```
isCorrect = 0;
diff = abs(input-solution);
if (diff<epsilon) isCorrect = 1;
```

Using the absolute value makes sure that we obtain a positive number for the difference. Note that number representations in a computer are never exact due to the limited number of bits available. Consequently, the difference of floating point numbers should never be compared to 0, but rather we need to make sure, that the difference is smaller than a certain epsilon. This also accommodates for rounding errors. In our implementation, we use an epsilon value of 0.001.

Vectors and Matrices. In order to compare matrices, we essentially have to compare the numbers for the corresponding rows and columns. Fortunately mathematic software makes this comparison easy. In fact, when using Matlab we can even avoid implementing nested loops.

```
isCorrect = 0;
diffmatrix = abs(input-solution);
maximum = max(max(diffmatrix));
if (maximum<epsilon) isCorrect = 1;
```

Note that we compute the difference matrix and then find the global maximum of rows and columns in the matrix. If this maximum is smaller then epsilon, the matrices are considered equal.

Intervals. Intervals are described by their endpoints and information of whether these are included in the interval or not. The interval $(1,3]$ e.g. includes all numbers between 1 and 3 excluding the number 1, but including 3.

To compare intervals, we need to parse the expression. First we look for the type of parentheses or brackets. Then, we split the left and right endpoints. Two intervals are considered equivalent, when their brackets match and when their endpoint numbers are identical with respect to the criteria described in paragraph 4.2.

Sets. Sets are unsorted lists of numbers. For verification, we sort the numbers to obtained an ordered list. This ordered list can now be handled in the same manner as a vector.

An implementation using MATLAB could look like this:

```
isCorrect = 0;
diffvector = abs(sort(input)-sort(solution));
maximum = max(max(diffvector));
if (maximum<epsilon) isCorrect = 1;
```

Functions. Comparing function representations is the most difficult among the presented solution types. We need to manipulate the provided expressions to make them match.

Given a user input of $x(x+1)$ and a solution x^2+x, we need to expand the input expression in order to allow a proper comparison. A straight forward expansion is not always sufficient to compare two symbolic expressions. In many cases, we have to do further simplifications, either for the user input and or the solution.

It might e.g. be necessary to simplify logarithms, exponentials or radicals. In such a manner, we can simplify an expression like $\frac{e^x-1}{1+e^{\frac{x}{2}}}$ to $e^{\frac{x}{2}}$. The algorithmic implementation details to perform these manipulations are described in (Fateman, 1972). They are readily available in state-of-the-art computer algebra systems.

In our implementation, we use the math software Maxima (Schelter, 2013) to do symbolic calculations. We compare function representations using the following code lines:

```
diff(x) := input(x)-solution(x);
simplified(x) := radcan(diff(x));
result(x) := expand(simplified(x));
```

Finally, we check whether the resulting function `result(x)` equals to zero.

5 CONCLUSION

In this paper, we have shown how an interactive feedback and assessment system tailored to math exercises can be implemented. The proposed system provides meaningful immediate feedback to students while practicing math. Thus, allowing them to better learn on their own without requiring human assistance in the form of a teacher. This helps to alleviate some of the frustrations student encounter when dealing with mathematic problem solving and is particularly important for online courses.

We leverage the capabilities of existing math software packages to analyze user input and to decide which feedback to generate. Thus, making the system a general math tool, where exercises may range form simple high school math to university level calculus and algebra.

For teachers, the system allows the use of a much wider variety of question types compared to standard e-learning systems, which are mostly restricted to simple multiple choice questions. It is easy for teachers to create their own exercises. Contrary to most tutoring systems no special programming skills are required. Exercises may be defined in a simple text format where formulas may be entered with the familiar LaTeX syntax.

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Teaching Computer Programming in Online Courses
How Unit Tests Allow for Automated Feedback and Grading

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Keywords: Online Courses, Computer Programming, Assessment, Grading, Teaching, Tutoring, Unit Testing.

Abstract: Online courses raise many new challenges. It is particularly difficult to teach subjects, which focus on technical principles and require students to practice. In order to motivate and support students we need to provide assistance and feedback. When the number of students in online courses increases to several thousand participants this assistance and feedback cannot be handled by the teaching staff alone. In this paper we propose a system, which allows to automatically validate programming exercises at a fine-grained level using unit tests. Thus, students get immediate feedback, which helps them understanding the encountered problems. The proposed system offers a wide range of possible exercise types for programming exercises. These range from exercises where students need to provide only code snippets to exercises including complex algorithms. Moreover, the system allows teachers to grade student exercises automatically. Unlike common grading tools for programming exercises, it can deal with partial solutions and avoids an all-or-nothing style grading.

1 INTRODUCTION

Basic programming is part of the syllabus of any engineering discipline. In fact, programming skills are required for many tasks ranging from automation to data analysis. There is a common consensus, that programming skills cannot be learned from books or lectures alone (Milne and Rowe, 2002). Consequently, programming courses are often accompanied with laboratory classes where students practice programming in front of a computer. Many courses also require students to hand in results of programming projects. Usually teaching assistants supervise students during these laboratory classes and projects.

For online courses we have to cope with new challenges in programming education. Firstly, direct interaction and assistance is more difficult. Online courses mostly use forums to answer student questions. This communication is tedious and since answers are often delayed by hours or days inhibit the learning process.

Even though desktop sharing software would allow for real-time assistance, we are not aware of any educational institution using this technology to a larger extent. In particular since online courses are usually designed for a large student audience, where individual assistance would be too time-consuming for the teaching staff.

When dealing with hundreds or even thousands of students it is also difficult to grade exercise sheets. Revising such an amount of source code manually is no longer feasible. Online universities like Udacity (Thrun et al., 2012) or Coursera (Ng and Koller, 2012) try to remedy this situation by using simple quizzes in their courses. These quizzes are often based on multiple choice questions and are graded automatically. Thus, allowing immediate feedback to the students. For some special courses e.g. (Thrun, 2013) customized tools are used to allow students to hand-in small computer programs. Currently there are, to our knowledge, no general concepts or available frameworks to deal with programming exercises of varying complexity, i.e. ranging from simple code snippets, class and interface implementations to medium or large programming projects.

In this paper we propose a software tool to evaluate different types of programming exercises in online courses. We leverage the capabilities of unit testing frameworks to analyze source code snippets or whole computer programs. Our tool allows teachers to easily create custom electronic exercise sheets which may be automatically analyzed and graded. Students receive individual feedback on their implementations via a web-based user interface. Consequently, they are able to evaluate their own learning process and success.

2 RELATED WORK

For the purpose of this paper, we divide educational software supporting programming education into two categories. The first category are intelligent tutoring systems tailored to support the understanding of fundamental programming concepts. The other category are automated grading tools which are also often used in the context of programming contests.

Intelligent Tutoring Systems. Tutoring tools for programming education date back to the early 1980's (Johnson and Soloway, 1984; Soloway, 1986). The goal of a tutoring system is to analyse student responses and gather information about the learning process (Brusilovsky, 1995; Corbett and Anderson, 2008). Thus, they are able to assist students, point out weaknesses and strength and suggest further study material.

Tutoring systems typically present learning units in small cognitive accessible exercises or dialogs (Lane and VanLehn, 2004). They may also coach students with hints, tips and additional information throughout the study process (Lane and VanLehn, 2003). This step-by-step process is not always appropriate. Teachers also want students to engage in more complex problem solving tasks without or with less guidance. These types of exercises often cannot be properly covered with tutoring systems.

The progress in research on intelligent tutoring systems has also been accompanied by the evolution of new programming concepts and languages. Particularly, the rise of object oriented programming languages has changed how programming is taught and how tutoring systems are implemented (Sykes and Franek, 2003). While object orientation is certainly the main focus of today's programming education, there are tutors for other popular concepts as e.g. functional programming (Xu and Sarrafzadeh, 2004). Modern tutoring systems are often web-based (Butz et al., 2004) with a central server analyzing source code, building student models and offering help and assistance to students.

Automated Grading Systems. The development of grading tools happened along two different paths. One motivation for their use were large scale programming contests, where students compete in solving algorithmic problems (Leal and Silva, 2003). Usually, problems are designed to require complex program logic, but to produce simple output (e.g. find the shortest route to escape a maze). Some contest software also evaluates source code and program metrics, e.g. number of lines of the implementation or program speed (Leal and Silva, 2008).

In recent years, grading tools have also become more popular as learning support tools, allowing teachers to spend more time working with students and less time grading course assignments (Tiantian et al., 2009; Hukk et al., 2011; Foxley et al., 2001).

Grading tools usually evaluate the correctness of a complete computer program. That is, a complex exercise is either correct or incorrect. For students this is often frustrating. A tiny error and their almost working solution is not accepted. When using such a system at our university we observed that it works well for the top students in a class. Weaker students, however, quickly loose their motivation and do worse than with conventional assignment sheets.

3 ASSESSMENT STRATEGIES FOR ONLINE COURSES

For online courses, we need elements from both tutoring systems and automated grading tools. That is, we want to support and guide students when new concepts are introduced. On the other hand, we want them to solve more complex exercises and evaluate these automatically.

In this paper, we propose a first step in this direction. Our system makes it possible to define exercises of varying complexity. We allow teachers to define exercises with step-by-step instructions similar to quizzes. But we also allow them to define more comprehensive exercises where students may practice algorithmic problem solving skills.

In order to accomplish this goal, we analyze the source code using a unit testing framework. With unit tests, we can test both program parts (e.g. a single method or function) or the program as a whole. Unit tests are on the one hand a familiar tool to any programmer and thus to any computer science teacher. On the other hand, they allow teachers lots of flexibility when designing their exercises.

The idea is to define many unit tests for a single exercise and test program parts instead of the overall functionality. As a consequence, we can return a more fine-grained feedback. Not only is this feedback helpful for students when solving the exercises, unit test also allow to attribute points to the individual parts of an exercise. We are convinced that this leads to a more transparent and fair grading result.

In the following sections we will show two small sample exercises as they have been implemented in our system.

3.1 Simple Exercise

A simple exercise is often used as part of a step-by-step learning process. It requires students to complete only a very small task or a subpart of a larger task. For programming exercises students are often required to fill in a small code snippet, e.g. a specific command.

In the example presented in Figure 1, the student has to insert a snippet for a mathematic operation. We will discuss the validation process for such a code snippet in section 4. Students receive feedback in the form of points, when the code is correct and error messages and hints are displayed if the snippet does not properly solve the exercise.

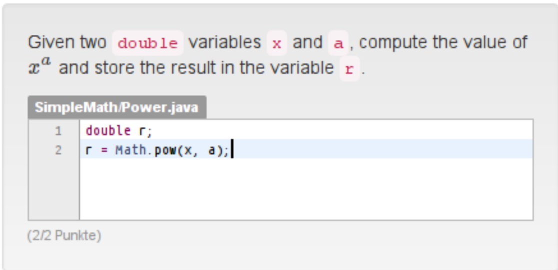

Figure 1: A simple exercise requiring students to enter a small code snippet.

3.2 Complex Exercise

For more complex problems, students typically need to fulfill multiple requirements. Even if the solution is a single class, method or computer program, we want to check for these requirements separately.

In Figure 2 a more elaborate exercise is shown. In this specific example a solution has to satisfy three requirements. It needs to implement a correct method signature with appropriate parameters. The method needs to return a correct return value and finally it has to produce a specific console output by extracting sentences from a text.

In order to check these requirements three unit tests have been implemented. Figure 2 displays a student solution, where only one requirement is met. For the other requirements meaningful error messages and hints are displayed. Thus, we avoid the all-or-nothing style grading and help students to build their solution incrementally.

4 IMPLEMENTATION AND EXERCISE TYPES

Most grading tools for programming courses only consider the final output of a computer program. This

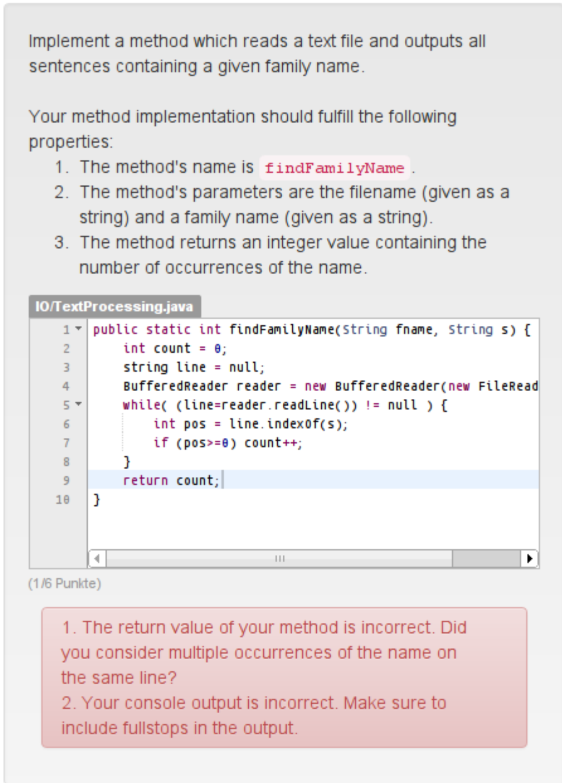

Figure 2: A complex exercise requiring students to implement an algorithm with a specified interface.

behaviour has serious disadvantages. Checking of console output is susceptible to small typos or differing whitespace characters (e.g. spaces, line breaks or tabulators). These little mistakes can be a source of frustration for students and we would like to avoid penalties for such errors.

Unit tests allow to check programs at a much more detailed level. In fact, we can check individual parts of the program in a type-safe manner. Thus, it is possible to define a much wider range of possible exercises. In the following we systematically present the most common types of exercises and the corresponding solutions.

Code Snippet. A programming exercise may require students to provide a small code snippet (see e.g. Figure 1).

In order to test such a code snippet with a unit test, it needs to be inserted into a surrounding main program. In most cases, this surrounding program defines a method, which returns a value that has been computed in the code snippet. Consequently, we check the return value and return type of this function.

For the example in Figure 1 a main program could look like this:

```
class Power {
  static double pow(double x, double a) {
    // CODE SNIPPET IS INSERTED HERE
    return r;
  }
}
```

Note that it would not be feasible to use simple string matching to compare a snippet to a pre-defined solution. There are many ways to rewrite code in an equivalent manner. E.g. the shorter expression `double r = Math.pow(x,a);` would work as a solution, too.

Method/Function. Exercises where students need to implement a specific method are naturally suited for unit tests. Again the student's implementation is inserted into a surrounding main program and checked via an appropriate test.

A unit test checking for a method with a computed return value could be implemented in the following manner (compare Figure 2).

```
class TextProcessingTest {
  @Test
  public void checkReturnValue() {
    int c1, c2;
    c1 = Sol.findFamilyName("f1.txt","Hill");
    c2 = Ref.findFamilyName("f1.txt","Hill");
    assertEquals(c1, c2);
    c1 = Sol.findFamilyName("f2.txt","Lee");
    c2 = Ref.findFamilyName("f2.txt","Lee");
    assertEquals(c1, c2);
  }
}
```

For the above example Java along with the JUnit testing framework has been used. For other languages and frameworks this would work in a similar way. Here we check the student solution inserted in the class `Sol` with the reference implementation in the class `Ref`. We compare the results for two different test cases.

Most algorithmic exercises can be tested using tests for one or multiple methods. Also note, that unit tests allow type-safe testing. Thus, we can also process and compare structured data types (i.e. objects) in parameters and return types.

Class with Interface When learning object oriented programming, students need to implement their own classes and data types. This includes the definition of appropriate member variables, constructors and methods.

Often an implementation has to conform to a specific interface, which then may be tested with the help of unit tests. The unit tests create instances of the defined classes and check the public member variables and methods.

While testing the interface of a class is mostly sufficient, some programming languages even allow us to inspect the classes and objects. This inspection is called type introspection or reflection (Forman and Forman, 2005) and it allows us to analyze a program at a very fine-grained level. Using this technology we can easily check the types of private member variables and signatures of class and member methods.

In the example below, we depict a unit test, which compares the return type of each implemented interface method with a reference type stored in a predefined array `returnTypes`. If the types do not match, the test fails and an error message is returned:

```
class PlayerInterfaceTest {
  @Test
  public void checkReturnTypes() {
    Method[] methods = \
      Player.class.getDeclaredMethods();
    for(Method m : methods) {
      Type t = m.getReturnType();
      if (t.equals(returnTypes[m.getName()]))
        fail("Return type of method " \
             +m.getName()+" is wrong");
    }
  }
}
```

Console Output. Finally, we can use unit tests to compare console output. Console output may be used to compare simple programs e.g. a Hello World program or the output of complex algorithms.

One way to do this with unit test, is to redirect the standard output to a string and then do a string comparison. For Java e.g. output redirection can be achieved by providing a new `PrintStream` object:

```
System.setOut(printStreamObject);
```

As pointed out earlier, comparing of console output is not type-safe and susceptible to typos and whitespace errors. This type of checking should therefore only be used for exercises which are designed to practice how to do console output. Other programs should be tested in a type-safe way using unit tests for methods and classes (see above).

5 EXERCISE WORK-FLOW

A practice and learning tool for students should be easy to use. The heavy-lifting of our implementation is therefore done on the server side and is transparent to the user.

The work-flow of an exercise is split into 4 parts:

1. Write and test in an IDE
2. Submit via web-based UI
3. Compile and validate on server
4. Feedback

Write and Test in IDE Students write their implementations in an integrated development environment (IDE). On the hand, we want students to learn how to use IDEs and their convenience features (e.g. code completion). On the other hand, this allows students to compile and run their code on their own test data before submitting it.

Submission. In our implementation exercise sheets are presented in a web-based user interface. In this same user interface submission fields are integrated (see Figure 1 and Figure 2). To support syntax highlighting of source code, we use the ACE Javascript editor [1] allowing students to have a convenient overview over the exercises and their respective responses.

Compile and Validate. Students results are received on a central validation server. The server preprocesses the input (e.g. inserting of code snippet in a main program) and handles the compilation. Compilation errors are reported back to the user interface via AJAX.

Once the compilation succeeds the code is checked via unit tests. For security reasons the compilation and testing is done in a sandbox. Additionally, the server makes sure that no endless loops occur in the student code. This is accomplished by a timeout setting defined in the unit tests. In JUnit this is achieved in the following way:

```java
@Test(timeout=1000)
public void testMethod() {
  // some test code
}
```

Here, the test fails, when its execution takes longer than 1000 milliseconds.

Feedback. As unit tests allow a more fine-grained analysis of the submitted code, we can also provide more detailed feedback to the students. In fact, meaningful feedback is particularly important for online courses, since asking questions in a forum and receiving an answer usually takes a long time.

The proposed system provides feedback to every defined unit test and of course run-time exceptions. This feedback is displayed along with the achieved points directly below the input in the web-based user interface. A teacher can customize this feedback and add additional assistance and hints (see Figure 2 and Section 6).

[1]http://ace.c9.io

6 CONTENT GENERATION

For teachers it has to be easy to create custom content. Interactive exercises therefore may be defined in a simple text format inspired by Markdown (Gruber, 2004). Input fields with their properties are specified with XML tags.

The example in Figure 1 may be created with the following text:

```
???  Math functions
Given two *double* variables *x* and *a*,
compute the value of $x^a$ and store the
result in the variable *r*.
<field:java file="Power.java">
   <test="CheckValueOfR" points="2"
    fail="The value of 'r' is incorrect.
    Make sure that the variable 'a'
    is the exponent.">
</field>  .
```

The character sequence `???` starts a new exercise with the title `Math functions`. The stars highlight the enclosed terms. The more structured XML part specifies which unit test to use and which feedback to return when the unit test fails.

From the above text format an HTML page for the web-based user interface is generated. Additionally, the unit test needs to be implemented e.g. as shown in Section 4.

7 CONCLUSION

In this paper we have presented an interactive learning and grading tool for online courses. The tool lets teachers create programming exercises, which are automatically validated. Students on the other hand get immediate feedback to their solutions and can therefore incrementally improve their abilities.

The proposed system implements a general concept on how to handle programming exercises of varying complexity. Our system allows teachers to use a much wider range of exercises and checks as it is possible with existing tutoring and grading tools. It allows to validate both small code snippets and complex algorithms via unit tests. These unit tests enable a more fine-grained analysis of the source code and a more detailed feedback.

We believe that this improved validation helps student to learn programming in a more efficient way compared to existing online courses. Moreover, the developed tools allow teachers to automatically grade large amounts of student submissions without having to rephrase exercises in the form of multiple choice questions.

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Security Aspects for e-Learning Portals

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Keywords: Distance Learning, e-Learning, e-Learning Portal, Information Security, Security Subsystems.

Abstract: Many safety problems are facing e-Learning portals (EP) developers to make it a trusted tool for e-Learning. The paper gives motivation of security implementation expedience for EP including a brief overview of typical attacks against EP. Further a generalised EP structure as a protection object is created and the key security requirements and functional security subsystem components of a secure EP are developed. In conclusion a real example of the secure EP on the basis of "DOCENT" distance learning system (DLS) by the Russian company UNIAR being used in the National Research Nuclear University «MEPhI» is shown.

1 INTRODUCTION

Today many educational institutions have their corporate information and telecommunication networks – Intranets, intended to integrate parties, processes and information within them. In general an Intranet uses the Internet-based technologies to facilitate communication and access to information with a common entry – portal (Jonas, 2008). At the Universities it usually contains a part designed especially for supporting e-Learning – an e-Learning Portal (EP). As an amalgamation of hardware and software applications, it provides a personalized single point of access to educational applications, content, parties and processes through one common user Web interface. The EP accumulates data from diverse internal and external sources, provides access to data by all users, presents information in the format appropriate for each of them, provides underlying services for such an applications as storage, processing, search, collaboration, workflow and security and also guarantee performance and availability. As a traditional portal, the EP has no client software dependencies beyond a Web browser.

The EPs have different specific aims and focus on guiding students through a structured learning experience and providing the necessary human factors support to increase the effectiveness of the portal as a means of an educational material delivery. The EP is a thematic guide to quality-controlled information and knowledge on the Internet, focusing on education and lifelong learning. Many of Distance Learning (DL) needs could be solved via the EP usage: permanent uniform administration and management over the whole educational process through a web platform; modern learning infrastructure accessible anywhere and anytime; cost-effective training through DL interfaces; personalised single point-of-access desktop to DL resources and applications; access to pedagogical resources through the possibility of referring to high-quality on-line resources from multiple sources through content syndications; effective integration of computer technology use into classroom curriculum in order to improve students' learning and achievement; communication and collaboration through e-mail, videoconferencing and threaded discussions. DL teachers have an access to relevant information for educational decision-making and are able to prepare and enter into the system lessons from home. The EP supports testing of students' abilities as they follow the courses, so include various forms of assessment. Assignment and examination materials and results must therefore be presented in a personalised and confidential way.

Unfortunately all of the listed objects and processes can become a target of unauthorized access by malefactors having various goals – to steal training materials and tests, to obtain a certificate without any real training, to arrange substitution while passing test and so on.

In DL both remote students and universities have direct security concerns. Thus problems of development, integration and maintenance secure subsystems supporting DL is highly urgent for many educational institutions.

2 RELATED WORKS

Problem of DL and security were discussed by various scientists during more than a previous decade. The necessity for securing online DL because of its use of the Internet as a communication medium was proved by (Furnell, Karweni, 2001) yet in 2001! They listed the following typical information security (IS) threats in DL content: malicious software such as viruses, worms, Trojan Horses, Denial of service attacks, masquerading, spoofing, fraud, data theft and so on.

The paper's authors experience in solving security problems in DL as a whole and for progress testing can be found in (Diatchenko, Miloslavskaya, Tolstoy, 2001), (Miloslavskaya, Tolstoy, 2003) and (Miloslavskaya, Tolstoy, 2004). But till now the given problems are still up-to-date.

At present not only data security should be supported – capturing of students' personal information and their privacy are becoming a source of growing concern (Siciliano, 2013). In (Kavun, Sorbat, Sorbat, 2012) authors consider the security aspects that are directly relevant to DLS and identify major elements of them (or subsystems-services): security mechanisms as identification and authentication and services like Web site, e-mail and ftp server. DLS should have adequate tools to protect content, personal data, copyrights and passwords from disclosure, attacks on its integrity and "denial of service" (DoS) attacks.

The given problems are thoroughly examined in many scientific works, conferences (like IEEE Symposium on Security & Privacy 2013, May 19-22, USA, San Francisco) and specially devoted to these issues The Open Web Application Security Project (OWASP) [http://www.owasp.org].

3 GENERALIZED EP STRUCTURE

Different EP structures should be generalized to pick out main DLS objects and processes requiring protection. The EPs consolidate, manage, analyse and distribute information across the identified learning community (not necessarily only University students, but also short term trainees, possible from another countries). Content Management Systems (CMS) process, filter and refine "unstructured" data and information, often restructure it and store it in a centralized/distributed repository. Business Intelligence tools access data and information and through querying, reporting, on-line analytical processing. Data Mining and Analytical Applications provide a view of information both presentable and significant to the end user. Data Warehouses and Data Marts are integrated, time-variant, non-volatile collections of data supporting applications. Data Management Systems perform extraction, transformation and loading, clean data, and facilitate scheduling, administration and metadata management for data warehouses and data marts. The Learning CMS (LCMS) is an environment that consolidates planning, building and evaluation of the learning/educational process and covers the tools for creating, arranging and consolidating content parts. As it can be seen even all the modern information and network technologies are used for EP functioning support.

Proposed general model of EP structure from Infrastructure, Learning Services and Applications viewpoints is represented in Figure 1.

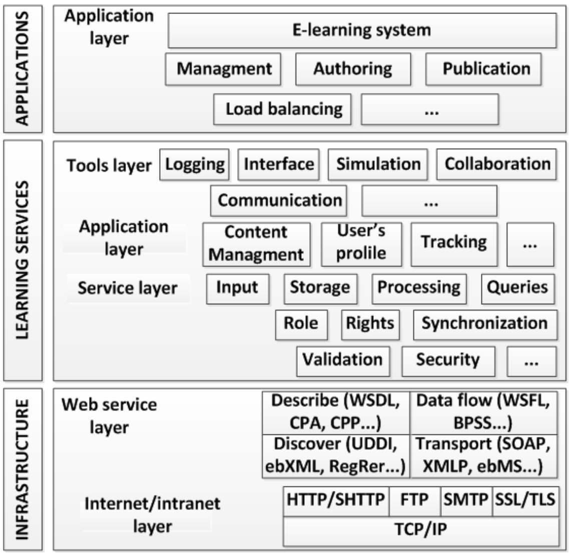

Figure 1: EP structure.

The Internet layer and its information flow protocols are used at EP Infrastructure. The EP utilizes HTTP/SHTTP for data transfer and FTP for uploading the materials. The SSL/TLS protocols are intended for session protection while an author or an administrator works with the resources. The SMTP (or ESMTP which is better from the security point of view) is used in the EP e-mail system. The SOAP, which is in the Web service layer of the Infrastructure, is used for making the data into packages and forwarding it to external sources. Data flow management protocols are also included in the model as well as discover and describe services.

Learning services, used in EP at higher levels, can be divided into the three groups – common services (for data processing), common applications (for DLS resources management) and tools layer (for logging, interfaces and communications). Applications' layer contains DLS itself, its management and different supporting subsystems (such as publishing and authoring).

4 TYPICAL ATTACKS AGAINST EP

Generally as a typical information system and a classical Web application any EP is subjected to all typical attacks on it. A quick search in the National Vulnerability Database [http://nvd.nist.gov] shows the following problems in DLS:

- SQL injection in search_result.asp in Pre Projects Pre E-Learning Portal allows remote attackers to execute arbitrary SQL commands via the course_ID parameter;
- PreProjects Pre E-Learning Portal stores db_elearning.mdb under the web root with insufficient access control, which allows remote attackers to obtain passwords via a direct request;
- directory traversal in user_portal.php in the Dokeos E-Learning System 1.8.5 on Windows allows remote attackers to include and execute arbitrary local files via a ..\ (dot dot backslash) in the include parameter;
- Multiple cross-site scripting (XSS) in Blackboard Learning System 6, Blackboard Learning and Community Portal Suite 6.2.3.23, and Blackboard Vista 4 allow remote attackers to inject arbitrary Javascript, VBScript, or HTML via data, vbscript and malformed javascript URIs in various HTML tags when posting to the Discussion Board;…

Main types of attacks on DLS can be divided into attacks on the DLS components and attacks on the participating parties – instructor/curator/ administrator and trainees. Here are some examples.

There is a possibility when trainees will try to get a certificate of successful training completion without studying all the provided educational material. To do this they will have to successfully pass exams/test/quizzes, but they may not be having sufficient knowledge on the subject. In that case the DLS interaction data and evaluation code can be potentially exposed (for example using a sniffer intercepting network traffic) and analyzed by a cheater to beat the test. The data collected through the DLS use interface can be analyzed offline. A malicious person can reconfigure DLS settings (of course under certain circumstances).

In practice all Web client-server architecture components (servers, clients and channels) are susceptible to very many old and modern security threats (executable because some vulnerabilities are still alive). For example two most widespread attacks on Session ID are XSS (it allows abducting Session ID from lawful users) and "phishing" (it lures the unsuspecting user to a fake web site looking and acting like trustworthy site).

CGI scripts usage is the next Web server threat, as far as many of CGI scripts contain program errors, which can be used as loopholes by malicious persons. In turn Java and JavaScript usage is one more problem to be concerned with. Unlike CGI scripts Java code is run on a client side and that is why cannot damage a Web server, but can contribute troubles to a client. Ensuring secure usage of Java and JavaScript is based on a browser used by a client. Many of these problems appear as a result of the errors in Java interpreters used by the browsers.

Plus possibility of theft and substitution of cookies – a small data piece sent from EP and stored in a trainee's web browser while the user is browsing that EP. Cookies can store passwords and forms a trainee has previously filled out, such as an address or a credit card number. The authentication cookie's security generally depends on the security of the issuing website (EP) and the trainee's web browser, and on whether the cookie data is encrypted. Security vulnerabilities may allow a cookie's data to be read by a hacker, used to gain access to user data or to the EP (with the user's credentials).

There is also a problem of construction of secure authentication and authorization subsystems while integrating several automated systems into a portal. As the majority of modern DLS are SCORM compliant (Sharable Content Object Reference Model) it is justified to look at SCORM security requirements. SCORM has no specific provisions to provide for content, sessions and test security. How to ensure that users are authenticated is also out of SCORM scope. So is ensuring that users cannot tamper with the software on their computer while experiencing SCORM content. The higher the stakes in a test, the more incentive there is for some learners to cheat. The Tin Can API is the newest, more secure version of SCORM, but it does not solve old DL security problems. The Tin Can API developers outline one of its advantages – Oauth usage. The National Vulnerability Database highlighted several records concerning Oauth vulnerabilities being found in 2012-2013:

- XSS in some IBM WebSphere Application Server (WAS), when OAuth is used, allows remote authenticated users to inject arbitrary web script or HTML via unspecified vectors;
- Cross-site request forgery (CSRF) in the omniauth-oauth2 gem 1.1.1 and earlier for Ruby allows remote attackers to hijack the authentication of users for requests that modify session state;
- DaoAuthenticationProvider in some VMware SpringSource Spring Security does not check the password if the user is not found, which might allow remote attackers to enumerate valid usernames via a series of login requests;
- tmhOAuth before 0.61 does not verify that the server hostname matches a domain name in the subject's Common Name or subjectAltName field of the X.509 certificate, which allows man-in-the-middle attackers to spoof SSL servers via an arbitrary valid certificate;
- Content Security Policy (CSP) functionality in some Mozilla Firefox, Firefox ESR, Thunderbird, Thunderbird ESR and SeaMonkey does not properly restrict the strings placed into the blocked-uri parameter of a violation report, which allows remote web servers to capture OpenID credentials and OAuth 2.0 access tokens by triggering a violation and so on.

On the other hand another technologies used in the EP (such as sharing documents, support for virtual, distributed working teams, usage of different communication tools and protocols, data repositories, publishing systems etc.) need protection against their own specific types of threats leading to different local and remote attacks. For example besides many basic possibilities many EP solutions have tools for students' works publishing that essentially increases risk of distribution of data containing malicious code: viruses, Trojan programs, malicious mobile applications etc.

Another big problem – how do you know that the person taking a test is really the person you are trying to test?

Therefore it is not exaggeration to conclude that at the moment the lack of affordable and reliable ways of authentication of the student in the learning process, and most important, during the distance intermediate and final control of knowledge does not give full confidence in usage of the distance testing system.

It is considered that the DL scenario principally demands attention to the following areas:

- authentication (the right person should present the right login and password to the DLS – no masquerading);
- accountability and access control (of all actions that can influence DLS security);
- confidentiality where it is necessary;
- availability (24/7) of all DLS components;
- protection of communications;
- non-repudiation issues;
- DL server with various data protection.

At present any DL server with all its databases and services can be investigated as a cloud. Its main IS problems are the very typical: data loss and data leakage, account or service traffic hijacking, insecure interfaces and APIs, DoS, malicious insiders, abuse, insufficient due diligence and shared technology vulnerabilities (Samson, 2012).

The given analysis shows that IS threats to EP are still exist and are not solved yet.

5 EP SECURITY SUBSYSTEM

Thus EP application must include robust security. EP application, such as that required by the consumer self-service solution, must include robust security. It means more emphasis on the EP resources' and clients' information security including such an important items as privacy, content integrity, recognition, accessibility, confidentiality, availability etc. It is reasonable to elaborate implied EP security requirements and a complex approach to their realization in the form of an information protection subsystem as an integral (build-in) part of a secure EP.

The majority of traditional universities can typically be seen to have a number of protection measures in place, such as anti-virus software, scanning and monitoring tools, prevention of unauthorized software installation, IT usage policy etc. But presence of written, approved, maintained and communicated IS policies for all EP components and users is critical. Without EP Security Policies (EPSP) there is no general DL security framework. They provide guidelines to users on processing, storage and transmission of EP resources and define what behavior is and is not allowed. EPSP consist of policies for user accounts and passwords, remote access, personal information protection and many others.

While many definitions of security mechanisms exist, for the sake of simplicity the list of key EP security requirements should be defined as follows: general security, authentication, fine-granted access control to EP resources, encryption, centralized security events audit (including control, account and analysis resources using and submitted user data verification) and also internal resources' protection.

The EP engine is responsible for the execution and rendering of EP logics. Well-designed EP technologies combine standard processes for inventorying and organizing sources of information, identifying users and owners of that information and establishing rules for granting and controlling access plus flexible administration models for cost-effective and time-efficient management.

The basic subsystems in the overall generalized secure EP are suggested in Figure 2 (it is generic and can be applied to practically all web sites/portals).

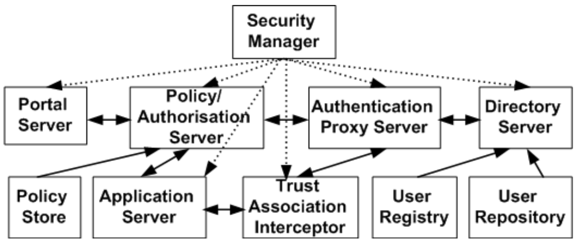

Figure 2: Secure EP Architecture.

The key component is a single, centralized *Security Manager* that activates required Security Services in addition to the other EP subsystems and coordinates all security tools managing a distributed, constantly changing e-learning environment. *EP server (PS)* uses one of the APIs to determine the access rights on a resource and different user interfaces for the learners, authors and DLS administrators. *User registry (UR)* is a database, containing user account information (user's ID and password) and used in the modern Single Sign-On systems. *User repository* is a database, which contains user profile information (name, address, already taught courses, gained certificates, educational schedule, etc.). *Directory server (DS)* provides the information from the UR and the User Repository. *Application server (AS)* is responsible for all basic EP services (including course access, assignments, collaboration and communication software, indexing engines, application gateways, knowledge applications, etc.), one part of which is Security Services. All the requests and responses are directed through the *Authentication proxy server (AP)*, responsible for managing the authentication process. It uses the DS to access the UR. A reverse proxy server is a component that is generally used to perform URL mapping and manage user sessions (for example with SSL/TLS authentication of both a client and a server) in order to protect the DLS Web site's structure from the outside world, but it can also be used for authentication. This would typically locate in a Demilitarized Zone (DMZ) of a University Intranet in front of the EP. The *Policy/authorization server (PAS)* is responsible for the IS management. It maintains the master policy store with authorization and access control data and offloads the tasks of authorization decisions to the PAS when requests are made. The *Policy store (PS)* as a repository of the groups and access control lists is used by the PAS for resources' access control. The *Trust association interceptor (TAI)* is responsible for establishing trust between the AS and the PAS. It validates any request and provides the user ID to the AS obtained from the PAS.

6 SECURE EP IMPLEMENTATION EXAMPLE

There are two possible ways of practical EP security implementation. First one is to buy one of the well-known portal solutions (such as Microsoft SharePoint, Oracle WebCenter etc.), relying on experts' estimations of their security. The second is to create an own EP software with all necessary Security Services and built-in (integrated) security subsystems. Such an approach allows to take into account all necessary security requirements, specific operation and environment from the very first designing stage and to ensure an efficient and holistic secure EP.

Implementing the EP security requires usage of some standard security concepts, for example, encryption (such as SSL/TLS), Virtual Private Networks (IPSec or similar) in University-trainee connection, enhanced protocols (such as ESMTP) and so on. Support for industry (such as LDAP, NTLM, NIS and NDS) and DL standards allows educational institution to easily carry over existing security profiles and meet even the strictest security requirements to their EPs. Monitoring tools used for analysis of all interactions with a Web server (IDS/IPS) should be also stipulated.

The EP made on the basis of the "DOCENT" DLS by the Russian company UNIAR is successfully used at the National Research Nuclear University MEPhI [http://www.mephi.edu] for 10 years. It is the first example of a secure Russian EP created according to the described modular approach (section 5). The "DOCENT" DLS security is provided by its functioning logic. It realizes protection against the most probable attacks. It is supposed that an intruder is an authorized EP user with only a browser (including those used in the mobile phones and pocket PCs). However it is enough for example to read the Web page contents and the entire client side scripts, which for example are not referenced anywhere (for example to the page, where correct answers to the quizzes are shown). He/she can transfer any parameters including forge ones. The EP security subsystem detects all these activities, reacts in an appropriate way and logs any attempts to compromise the EP.

Security subsystem logic consists of several business classes, incorporating all functionality supplied by the described in Figure 2 servers plus logging audit messages about all actions performed by the users. Protection against information substitution and deleting is also implemented via strict access control. The authentication scheme is based on the data, never saved to disk and destroyed if the browser is closed. All administration pages are accessible only through the HTTPS connections. Because the clear-text password can be sniffed the administrators are required to authenticate themselves to the EP with their personal certificates. Payload protection protocols used are SSL/TLS with encryption facilities.

The "DOCENT" DLS is used very effectively in the University's DL process for the University's students, bachelors and masters (as a part of the blended learning), at the short-term training courses and during an assessment of the trainees from the other Russian universities and NRNU MEPhI's partners (when we serve as a certification center). More than 10000 learners of different ages and preliminary education have already experienced all its advantages.

The "DOCENT" DLS is permanently improved. Its first versions suffer from a few typical attacks as data sniffing and DoS attacks. Their analysis showed the need to protect information in almost all stages of DL process. Stronger protection against attacks on EP communication channels and counteraction to DoS and DDoS (distributed DoS) attacks are going to be implemented.

7 CONCLUSIONS

Our many years' experience shows motivation of IS implementation expedience for EP and that to resolve DL IS issues completely and generally is a very hard task. DLS as they use network protocols, operational systems, databases management systems, different network services, Web applications, APIs etc. always inherit their vulnerabilities. A generalised EP structure as a protection object is created and the key security requirements and functional security subsystem components of a secure EP are developed. A secure EP on the basis of "DOCENT" DLS (UNIAR) being used in the NRNU MEPhI is shown.

In any modern DLS proactive EP security against new more and more sophisticated attacks is very welcome, but at present unfortunately nobody knows how to realize it in DL. The only way to reach the higher level of the DLS security is to conduct a full IS risk processing cycle for a concrete DLS in its particular content. After all IS objects, threats, vulnerabilities and risks will be defined and estimated it will be possible to create an adequate DLS security subsystem as it described below.

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Teaching the Arabic Alphabet to Kindergarteners
Writing Activities on Paper and Surface Computers

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Keywords: Early Childhood Education, Writing, Arabic Language Learning, Tabletop Surface Computers.

Abstract: This paper presents initial results regarding writing activities in the context of the ALADDIN project. The goal of the project is to teach Modern Standard Arabic in 5-year-old kindergarten students in Qatar. A total of 18 students, enrolled in the 'Arabic Class', participated for 9 weeks in the activities of the project. All students were native speakers of the Qatari dialect. Learning activities involved both typical instructional methods, and the use of specifically designed tools for tabletop surface computers. The paper focuses on writing activities and on how the affordances of surface computers affected students' performance and attitude towards the Arabic class and, consequently, the Arabic language.

1 INTRODUCTION

The general scope of our work in the 3-year long ALADDIN (Arabic LAnguage learning through Doing, Discovering, Inquiring, and iNteracting) project is to teach Qatari students in kindergarten Modern Standard Arabic (MSA) and help them understand the connection between MSA and the dialect. This research draws extensively upon the works of Ibrahim (2000, 2008a, 2008b, 2009) pertaining to Arabs language attitudes, the relatedness of the MSA to the dialect and the native speakers awareness, lexical separation as a consequence of diglossia, the use of technologies in Arabic language learning, and language planning and education.

At the age of 5, native speakers in Qatar follow a rather scholastic instructional method, based mostly on Behaviorism, following trial-and-error and mnemonic tasks. At the same time, children are exposed to both the MSA through the Media and to the Qatari dialect spoken at home and in everyday life. Unfortunately, very little research, if any, has reported on the state of the Arab children's vocabulary at the age of five when they start schooling. Saiegh has done few, but very crucial, studies on the effect of diglossia on children's' learning (2003, 2004, 2005, 2007). The "scholastic way," which does not go well with new innovative technologies and methods of teaching, actually makes the students feel far from their actual surroundings.

In this context, the ALADDIN project aims to teach students, by introducing a new comprehensive curriculum based on a communicative approach utilizing listening sessions, narratives, discussion, educational games, and new technologies (i.e., tabletop surface computers) (see Papadopoulos et al., 2013, for more information).

The learning goals for the kindergartner students are to (a) recognize, and (b) produce the letters of the Arabic alphabet. Recognition refers to visual and audio recognition of a letter, while production refers to students' ability to write the letters. The research questions addressed in the paper focus on the latter, analyzing (a) how the affordances of tabletop surface computers alter the learning experience, and (b) the impact of this new technology to students' performance and behavior.

2 BACKGROUND

2.1 The Arabic Language

Arabic is a diglossic language, it has a high form used in all formal contexts (MSA), and a low form used in all daily contexts (Ferguson, 1991). It consists of 28 consonants, 3 long vowels, and 3 short vowels. Short vowels are not written within the word, but either above or below the letter. Arabic writing has four major characteristics that distinguish it from other languages: (a) writing is from right to left, (b) most letters are connected in both print and handwriting, (c) letters have slightly different forms depending on where they occur in a word, (d) Arabic script consists of two separate "layers" or writing, a basic skeleton made up of consonants and long vowels, and the short vowels and other pronunciation and grammatical markers.

2.2 Surface Computers in Language Learning

The benefits of multimodal tabletop displays for educational applications seem endless. However, few studies have specifically examined the cognitive and pedagogical benefits of multimodal tabletop displays. Finding related literature specifically for early childhood education and language learning was even more challenging. Similarly, a variety of writing apps is available for tablet PCs (e.g., ReadinRockets.org provides a list of the top 9 writing apps). However, literature is still missing on the systematical use of similar applications for tabletops in formal education.

Research reports encouraging results so far. Kerne et al., (2006) discusses the roles for interactive systems enabled by touch screen devices in supporting creative processes and aiding in idea formation. The touch screen devices facilitate the collection and manipulation of images, texts, and voice annotations in a composition space. As documented in Piper (2008), the use of multimodal tabletop displays, as a rich medium for facilitating cooperative learning scenarios, is just emerging. Morris et al., (2005) examined the educational benefits of using a digital table to facilitate foreign language learning. The application allowed four language learners to sit at the tabletop display and cooperatively categorize facts about various Spanish speaking countries.

The horizontal form factor of a multitouch tabletop surface provides a unique opportunity for shared interfaces allowing multiple people to simultaneously interact with the same representation. The use of touch technology was essential in our project, since kindergartners usually lack the ability to use a computer. This, along with the shared interface that would enhance peer interaction, made the use of tabletop surface computers a better choice for our context. One obvious drawback for using this kind of technology is the high cost of the system (especially since we needed 5 tables to accommodate the whole class). However, one should also consider the fact that this type of technology is gaining ground and it is expected to reach a wider audience and that could also mean a drop in prices. In addition, the ability to transfer part of the material or even have future versions of the project suitable for student-owned tablet computers could also provide argumentation for such a costly solution.

3 METHOD

3.1 Participants

The study was conducted in a private kindergarten school in Qatar. Students were grouped into several classes of, approximately, 20 students. One of these classes was assigned by the school to participate in the project activities, taking into account schedule flexibility, space requirements, and parents' consent.

Our class had 18 Qatari students (9 boys and 9 girls). All students were between 5 and 6 years old and they were enrolled in the 'Arabic Language' course. Students were native speakers of the Qatari dialect, but novices in MSA. The goal of the course was to teach students basic linguistic skills in MSA: vocabulary development, letter recognition and writing, and pronunciation. The total population of the class was present only 8 times in the 9 weeks for various reasons (e.g., illness), while most of the times the actual population was 16-17 students.

3.2 Design

The study lasted 9 weeks and during that time the instructional goal was to teach students the standalone form of the Arabic letters. The research design follows an empirical case-study approach. Listening, discussion, writing, and gaming activities were used throughout the semester to complement the introduction of a new letter.

Usually, a new letter was introduced by the teacher during the listening and discussion sessions. Next, the writing activities would follow, and later the educational games. The study utilized observation and system log files to assess students' performance and attitudes during writing.

3.3 Material

The writing activities were performed in two ways: on paper, and on the surface computers.

3.3.1 Writing Activity on Paper

For the on-paper activity, the students used A4-size sheets. A grid filled with dashed outlines of an Arabic letter was on the each sheet and students had to trace the dashed letter with a black pencil. The students were able to use erasers and the activity was over when the entire sheet was written. This writing activity was considered a closed-type one.

The students were sitting in desks for this activity. The sheets were not part of the new curriculum, but the typical instructional tools used by the school.

3.3.2 Surface Computers

The tabletop surface computers we use in the project (http://www.samsung.com/us/business/displays/digital-signage/LH40SFWTGC/ZA - referred in the rest as 'table') have a 40" touch screen that can recognize more than 50 simultaneous touch points making it possible for several students to interact and participate in the same activity. In addition, the size of the screen is large enough to divide the interface in smaller areas and have activities with 4 students per table. The students were standing up around the table while using it.

The technology used by the table is based on infrared detection and not on touch itself, having both pros and cons for our activities. By basing touch detection on shadow recognition, the table was able to interact with tangibles. For example, placing an object on top of a button is similar to pressing the button. On the other hand, relying on infrared resulted in a number of unintentional touches (e.g., loose clothes creating shadows on the table).

3.3.3 Writing Application for Surface Computers

Figure 1 shows the interface of the writing application for the surface computers. The application provides a writing pad to each of the 4 students siting around the table. Each pad resembles a typical notepad with lines and a white background that contains: a written letter with and without arrows that show the correct way of writing, several outlined letters for the students to trace, and empty space for writing the letters without scaffolding. Writing can be performed either by touching the tabletop directly with a finger, or by using an object like a brush. Either way, we fixed the thickness of the written strokes at 3 pixels for better results and clearer outcome.

Each writing pad comes with five tools: the writing mode tool that can be used to switch between write/erase mode, the undo tool for erasing the last written stroke, the color picker for selecting the color of writing, and the three lines and the two lines tools to change the number of the lines and the size of the letters appearing in the pad. In the beginning of the curriculum, the teacher may advise students to write letters using the two-line pads, as it would be easier for novice students to write bigger letters.

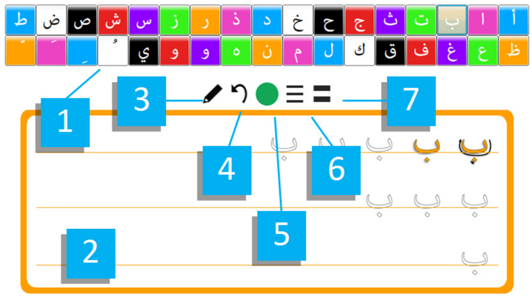

Figure 1: Writing application. 1: Letter bar; 2: Writing pad; 3: Write/erase mode; 4: Undo; 5: Color picker; 6: Three lines; 7: Two lines.

Every time the students select a letter from the letter bar or change the number of lines, the strokes written on the pad are stored in a local image file and the pad is cleared. No personal information is recorded and students' anonymity remains intact. The activity is open-ended and students can keep writing and erasing for as long as they want.

3.4 Procedure

Students have the Arabic Language course four days per week, at different hours. The class typically lasts 40 minutes, however, because students have to switch classrooms between classes and since there is not always a break between classes, the actual duration of the class is usually 30-35 minutes.

Typically, the students were engaged in a writing activity (on paper or on the tables) every time a new letter was introduced. The class was controlled by the school teacher, while the principal investigator of the project was also in the classroom to observe and take notes. Although specific guidelines were provided for each class by the new curriculum, the teacher very often had to adapt the schedule to address, mostly, time issues. Students were supposed to write the letter both on paper and on the tables. However, time limitations dictated skipping one or the other mode for some of the letters.

Students used the writing application on the tables at least once per week, spending approximately 5-10 minutes for each session. For the first 4 letters, students participated in the on-paper activity before doing the on-table activity. The two different modes were used on different dates. After the fourth letter, the procedure was switched and the on-table activity was performed before the on-paper one. The reason for this was that we wanted to examine whether the order in which the students learn how to write a new letter affects them in any way.

The students were distributed to the 5 available tables in the classroom by the teacher. Although organizing students into groups of 3-4 persons was mostly done randomly, factors such as gender, interpersonal relationships, and general student performance were often taken into account by the teacher, in order to have a balanced distribution. Group formation and students' spots were changing in each class, and, while it was not encouraged, students changing spots during a class was not forbidden either. Since the writing application contained 4 writing pads, each table could support up to 4 students.

We decided to give students paint brushes to write on the tables instead of having them using their fingers. This decision aimed at two things. First, we believed that it would feel more natural for the students to write holding a tool resembling a pencil. Moreover, supporting students' skills in holding a pencil was also a learning goal for the kindergarten. Second, holding a brush for writing diminished significantly the number of accidental touches, since there was now a distance between the table surface and students' forearms.

The use of paint brushes was highly accepted by the students. Specifically, a few weeks into the study we asked students to start writing using their fingers. After a few minutes, the students started asking for the brushes, stating that they prefer writing with them. One should take into account that by that time the students were using the tables for additional activities in the curriculum, apart from writing (e.g., educational games), where they would only use their fingers.

3.5 Data Analysis

To evaluated students' performance and attitudes in the writing activities, we used three sources of data. First, we received photocopies of the paper sheets the students used for the on-paper activity. Students' names were covered to preserve their anonymity. The second source of information was the log files collected from the 5 tables used in the classroom. As we mentioned earlier, the writing application was capturing students' strokes on the tables producing image files. At the end of the 9 weeks, this massive volume of images was analyzed and compared to the respective paper sheets. Finally, the principal investigator of the project attended every class and took notes throughout the 9 weeks, underlining important events and issues that helped us interpreting the rest of the data.

4 RESULTS

During the 9-week span covered by the study, the students learned the first 12 letters of the Arabic alphabet (from [أ] to [ز], considering 'alif' and 'alif with hamza' two different "letters"). After discarding empty images and scribbles, we collected 752 images from the tables.

Students practiced the writing of the first 4 letters on paper and then on the tables. Results between paper and tables were similar up to that point, with no distinct differences in students' writing or penmanship. In addition, the students were able to familiarize themselves quickly with the tables and minimize unintentional touches.

After the fourth letter, students practiced writing on the tables first and on paper second. What we observed was that after that point students felt more and more comfortable with writing letters. At that point students' behavior in class was increasingly positive as they accepted the various aspects of the new curriculum (e.g,. listening sessions, educational games, discussion sessions). However, when it comes specifically on their attitudes towards the writing activity, students' comfort level was evident by two facts, the appearing of drawing and the use of more colors.

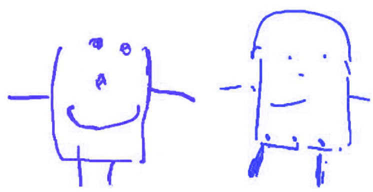

Figure 2: Student drawings on the writing application.

Students started drawing pictures, both on the tables and on the remaining space of the paper sheets after finishing writing the letters. The first pictures appeared in the tables in the fifth letter covered by the new curriculum, the 'thaa' [ث]. Two students used the shape of the letter as the mouth, eyes, and nose of a figurine (Fig. 2).

After that point, the number of drawings increased gradually with more students drawing flowers, hearts, houses, and items that start with the target letter (finding items that start with a specific letter was an important discussion topic during the introduction of a new letter). In the next letter, drawings appeared also on the paper sheets and after that it was a common sight (Fig. 3),

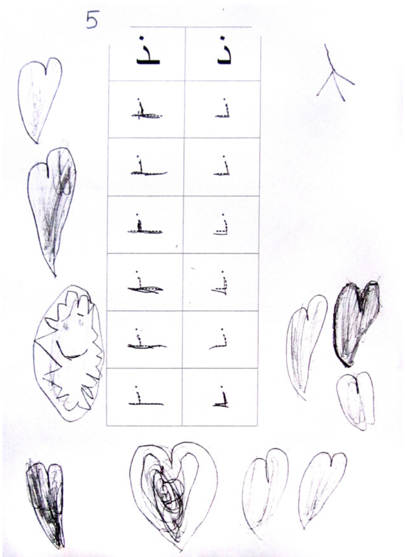

Figure 3: Student drawings on paper sheet for the 10th letter ('dhaal' [ذ]).

At the same time, students working on the tables started using the color picker tool more, thus adding different colors. This action suggests that student were now more engaged in the activity, as they were trying to make their writing more appealing. This option was not available for the on-paper writing, since students had to use pencils.

While writing a letter was an individual activity, when working around the tables, students started collaborating by helping each other adding more colors, erase unwanted strokes, and selecting the right letters to write. The same did not happen during the on-paper writing, since that activity was more structured and closed-type.

One issue we observed was that, in the beginning, students were writing the letters with strokes from left to right. This is usually the preferred way for languages that read from left to right. However, the proper way of writing a letter in Arabic is from right to left and from top to bottom.

English is the primary language of instruction in Qatar (in kindergartner, a student has 1380 minutes of teaching in English and 320 minutes in Arabic, per week). Thus, it was expected that writing would be affected by the teaching of English. Up until the letter 'jiim' [ج], the students were using the wrong way. However, after that they started writing correctly. A major reason for this, other than repetitive instruction and the arrows that appear next to the letters in the writing pad, was the shape of the letter that forced them to start from the correct side, while the letters up to that point allowed them to start from both sides.

After the positive feedback we received, having the students working on the tables first, we decided to keep this order for the rest of the curriculum. Students' ease and confidence in writing was apparent, as they started gradually to fill the whole writing pad in the activity, moving from the 2-lines pad to the 3-line pad on their own (Fig. 4).

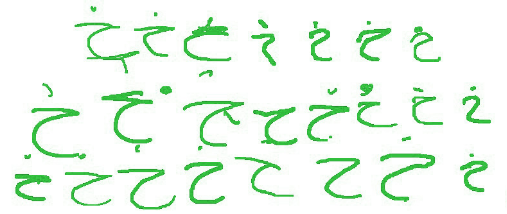

Figure 4: Student writing on the table for the 9th letter ('khaa' [خ]).

Specifically, results showed a few tries with the 3-line pad since the beginning (Fig. 5). However, most of the images showed only unsuccessful efforts, since students were not yet familiar. On the contrary, starting at the 8th letter ('khaa' [خ]), students started using the 3-line pad more often, filling the whole pad most of the times.

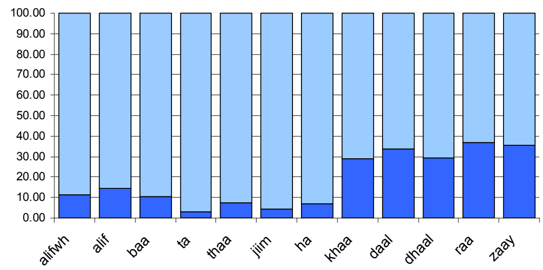

Figure 5: Usage percentage of 2-line (light) and 3-line (dark) pads.

5 DISCUSSION

In general, students developed a very positive attitude towards the project and the writing tasks. Having students practicing on the tables first had a significant effect, as they became more relaxed and confident. We argue that the characteristics of the tables were responsible for this finding. The open-ended nature of the writing application allowed students to be more creative. Writing was not about tracing dashes on a paper anymore. In addition, the ability to easily erase part, or the whole, of the writing pad with a single touch was a cleaner and easier option than the erasers used on paper, providing also an infinite supply of virtual sheets. Students were not afraid to make a mistake, since it was easy for them to erase it. This also resulted in the high volume of images collected.

The traced letters and the arrows in the writing pad were there to assist students. However, most of the space was left blank. Students did not complain about that. On the contrary, they took the opportunity to write freely. After they changed their attitudes towards writing, they started feeling more comfortable with the paper as well.

Regarding the novelty effect, the tables were, indeed, something new for the students. However, as we mentioned earlier, students of this age are already familiar with touch technologies and their excitement for a technological tool itself does not last long. In other words, students' enthusiasm for the tables was useful in the beginning, but it was not the reason for sustaining a positive attitude throughout the study. More than the technology effect, what the tables did was to change the learning experience for the students. Students were standing up and they could move from one table to the other. Peer interaction and, in some cases, peer collaboration were boosted. We believe that this affected students more than the technology itself in the long run.

In time, students became more confident. The increase of 3-line pads provides evidence on students' performance. However, confidence in students in the study was evident also in other activities of the project. As the teacher noted, students in the project class were more talkative and outgoing than students in other classes. This was of course the result of a instructional design utilizing many different learning activities, with writing being one of them.

We need to clarify that we are not suggesting the complete replacement of the on-paper with a technological one. Holding a pencil and writing on a paper are two essential skills for young learners. Nevertheless, the use of this technology provided us with new opportunities in supporting enthusiasm and engagement, while teaching writing to 5-year-olds.

ACKNOWLEDGEMENTS

This work has been funded by a grant from QNRF (Qatar National Research Fund), NPRP Project 4-1074-5-164 entitled "Advancing Arabic Language learning in Qatar". The authors would like to thank Christos-Panagiotis Papazoglou and Sachin Mousli for their contribution in the developing phase.

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A Cyber Laboratory for Device Dependent Hardware Experiments in a Hybrid Cloud

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Keywords: Remote Laboratory, Hardware Logic Design, Cloud Computing.

Abstract: The paper proposes a cyber laboratory in the form of a hybrid cloud, where the actual laboratory and the remote laboratory are combined. At the existing physical experiment laboratory, the limitation of the number of experimental devices for FPGA hardware design course resulted in platform usage congestions and extended laboratory hours. Migration to the cloud should be the natural solution. However, existing devices such as FPGA evaluation devices and Logic analyzers became obstacles to migrate to public clouds. The proposed system combines an On-Premise private cloud organized by laboratory platforms to perform device dependent services, and a public cloud where remaining design, development and evaluation stages, are carried out in the form of a PaaS (Platform as a Service). The design and experiment tasks should be modified accordingly to accommodate CAD tools in the set of the Web Services. Existing faculty database server and educational support system combine the private cloud, the public cloud and the faculty servers, in a seamless way. Students can migrate to and from laboratories at any design stages. As the device dependent tasks have been implemented in the Web Services, efficient sharing of platforms can be achieved in space and time sharing fashions. The public cloud ensures a scalable increase and decrease in server machines according to the student usages and seasonal load changes. The laboratory managing software takes care of the allocation and migration of student Virtual-Machines between the On-Premise private cloud and the public cloud. It can also accommodate the BYOD (Bring Your Own Device) style student usage, by preparing three different access methods: student side BYOD applications, the Web accesses and remote desktop connections. The hybrid cloud approach achieves a scalable realization of the cyber laboratory suitable for the BYOD style experiments, where efficient sharing of On-Premise laboratory platforms can be realized in the mixed use of actual and remote laboratories.

1 INTRODUCTION

The author has been engaged in remote laboratory projects and combining them to the actual laboratories (Koike, 2012, Fujii and Koike 2008). Hose University accepts around 100 new undergraduate students each year to take the hardware design course, utilizing twenty FPGA-based design platforms including logic analyzers and function generators. Students also share twenty PC-based Logic analyzer/function generators. Allocated time for the class is three hours per week. So, four students share one platform as an average. Schematic entry approach and Verilog-HDL design approach are both employed in the coursework. Each student is expected to design his/her own 32 bit CPU as the final project. The 32bit CPU design by making use of Verilog-HDL/logic synthesis tools, implementation in a FPGA evaluation board and verification of the designed hardware by running test software, are complex tasks and time consuming but it is effective for undergraduate students to acquire enough knowledge and skills in the field. Such a real life experience in the actual laboratory is very important and rewarding for developing student carrier. It is desirable for students to continue their experiments outside the actual laboratory. The author started the remote laboratory project, and tried to combine the remote laboratory with the actual laboratory. The former effort to access remote experiment sites (Hassan, 2012) only achieves the functionality of remote experimental data access via Web browsers. It had no control of remote experiment devices. Also, there are many efforts to migrate campus environments to the cloud computing, e.g. (Kumar, 2012; Hassan, 2012). In such a cloud configuration, the remote desktop services should be employed for remote experiment device accesses. However, they have their scalability problems due to the exclusive use of On-Premise laboratory devices. The author's former implementation (Koike, 2013) adopted the On-Premise private cloud solution. However, the laboratory platform/servers become a bottleneck, if the number of simultaneous remote laboratory users is increased. It is also difficult to support recent BYOD style student usages, as the former system heavily relied on student side powerful laptops, where time-consuming, latency-sensitive tasks can be executed locally by offloading them from the laboratory platforms. However, BYOD devices could not meet such performance requirements. Addressing these shortcomings, the author started the new cyber laboratory project, which combines the On-Premise private cloud and a public cloud in a seamless way, namely the Hybrid Cloud solution. On-Premise private cloud computers only perform device depending services in the form of the Web Services. The remaining services have been migrated to public cloud computers. If a student is accessing through the university-leased high-end laptop, it can still exploit student's laptop PC powers, by migrating time-consuming services, such as logic entry, simulation and verification to the laptop, in the form of native Windows applications. On the other hand, for the BYOD case, the allocated Virtual Machine in the public cloud acts as a BYOD proxy for the user. The proxy performs most of the works and the communications with the BYOD can be carried out via remote desktop, BYOD applications or http connections. In this way, it can achieve a scalable increase in the number of public cloud computers, according to the students' actual usages, and also it can decrease during off-seasons. It can drastically reduce the TCO (Total Cost of Ownership).

By combining those technologies, highly scalable and flexible cyber laboratory can be realized.

2 SYSTEM CONSIDERATIONS FOR CYBER LABORATORY IN A HYBRID CLOUD

In order to give students real life laboratory experiences, it is important to realize almost the same laboratory environment both in remote and actual laboratory modes. The efficient sharing of the laboratory platforms and their devices becomes important for realizing a scalable Cyber Laboratory. In case of the remote laboratory mode, most experiment tasks can be offloaded on the public cloud, except device related works, such as FPGA setup/run or logic-analyzer setup/get results.

Thanks to the advancement in cloud computing, implementing the laboratory computer environments in a public cloud becomes advantageous to reduce total cost of ownership. However as said, laboratory devices, such as Verilog-HDL synthesis tools, FPGA evaluation platforms, Logic Analyzers and pattern generators have made it difficult to migrate to the public cloud. Instead, the author's previous system, have chosen an On-Premise private cloud solution. On-Premise private cloud allows any connections of propriety devices to the On-Premise laboratory platform computers to organize as a private cloud. Although it achieved an efficient sharing of laboratory platforms/servers, it has its own scalability problem. If the number of remote laboratory users is increased, the server becomes overloaded and resulted in higher latencies and longer elapsed time. The former system also took advantage of students' high-end laptop PC performances, to offload time consuming tasks to the laptops. Thus, effective offload of laboratory platforms was realized. However, this approach becomes difficult to adopt for recent trend of BYOD (Bring Your Own Device) style student usages. Usually, BYODs are rather poor in CPU performance. It is better to offload such laboratory PC loads to computers in a public cloud. So, a hybrid cloud organization, where the On-Premise cloud performs device dependent tasks and the public cloud performs rest of the works, allows the realization of a flexible and scalable Cyber Laboratory.

The Figure 1 shows the Cyber Laboratory System organization, which have been designed based on the followings design considerations:

-Use of Special devices in the On-Premise private cloud: The requirement to connect specialized devices became an obstacle to choose a public cloud solution. Instead, an On-Premise private cloud solution has to be employed. However, the amount of workloads should be as little as possible. Only, device-related tasks such as FPGA Load/RUN, Logic-analyzer setup /measurement /results, should be remained in the laboratory platform (private cloud computer). The rest of the workloads should be offloaded on the public cloud. Only when device related services have been requested, the Web services should be generated and sent to the laboratory platforms. In order that such device dependent tasks can become accessible through the internet, they should be first transformed into Windows applications, and then encapsulated in the form of the Web services. If a student virtual machine is resided in the same laboratory platform, it realises an actual laboratory environment. The virtual network connection provides enough bandwidth to connect them. Nowadays, various system software for building such a private cloud, are available (Hasan 2012). So, the system development efforts and system management works can be remarkably reduced. The system manager only set the policies and the rest of the works can be handled semi-automatically. Students can find out an appropriate platform and log-in through the "dash-board" monitoring page of the Cyber Laboratory Manager in a self-serviced manner. It performs VM allocations/ migrations, server assignments and cloud storage link setup/ synchronization.

-Use of public cloud for handling non-device-related services: Non-device-related tasks can easily be offloaded to the public cloud, once they have been transformed into Windows applications and again encapsulated in the Web services. For each student one virtual machine is allocated in the public cloud, thus the remote laboratory environment is realized. In case when device-related services have been requested, these services should be forwarded to one of the private cloud computers in the remote laboratory service mode.

The use of the public cloud allows an efficient computer usage, as the number of actual computers can be flexible, according to the student usages and seasonal load variations. Each student is allocated an individual virtual machine, which can be migrated between private and public clouds, according to the actual /remote laboratories or mixture configurations of them.

-Adoption of the BYD style student use: The cyber laboratory managing software should detect the student BYOD devices and set up an appropriate service either in the private or public clouds. If the student is using the University-leased laptop, most design tasks, except the license logic synthesis tool and actual FPGA device use, can be offloaded on the laptop, and the student can enjoy a comfortable experiment. In case when Logic synthesis and FPGA run services have been requested, the resident software issues the corresponding Web services to

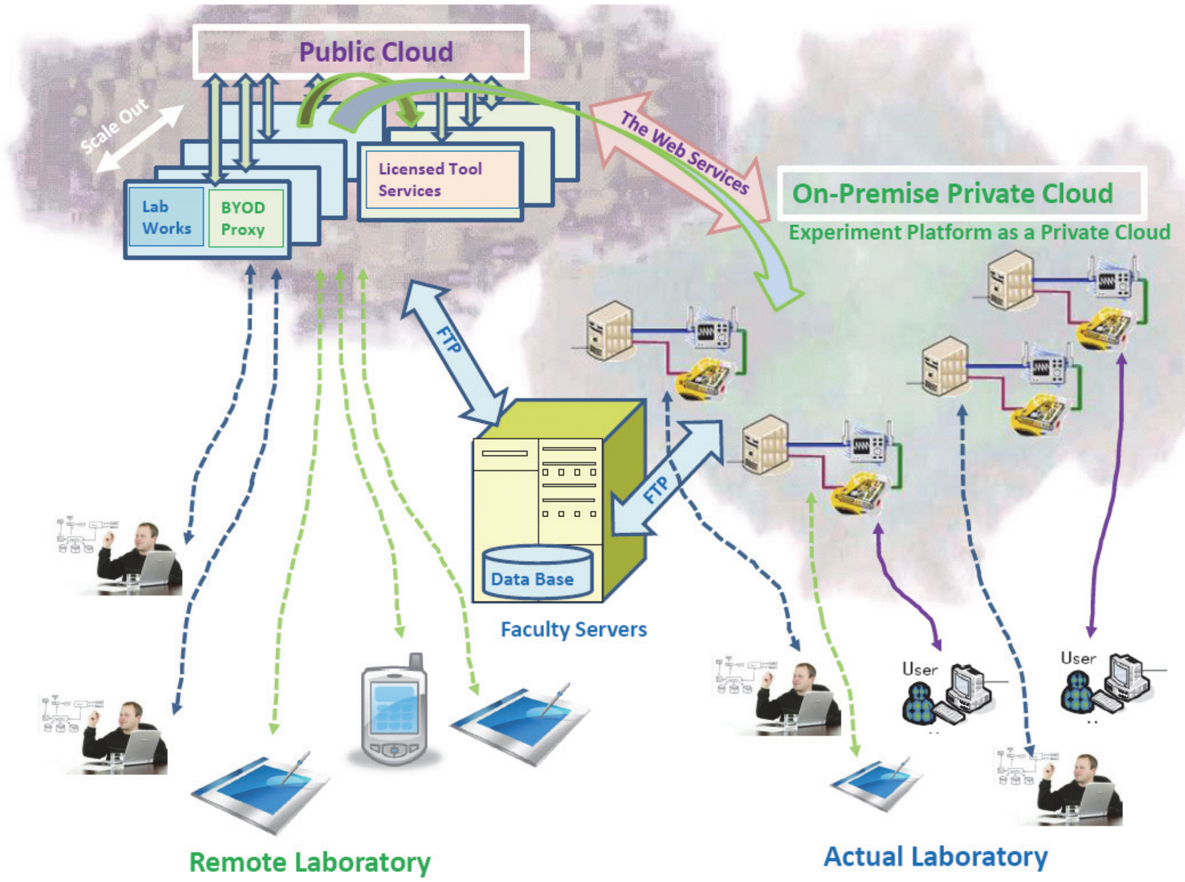

Figure 1: Cyber Laboratory in a Hybrid Cloud Organization.

the On-Premise private cloud. In case when the use of non-laptop BYOD is specified, one virtual machine is allocated as a proxy in the public cloud. The proxy performs most laboratory works. Only when the device related services have requested, the request is forwarded to one of the platform servers in the private cloud, via the Web services.

-Cyber Laboratory managing software handles allocations of the actual and remote laboratory Virtual Machines (VMs): It manages all setups of laboratory machines (private cloud), and the remote laboratory machines in the public cloud. The Cyber Laboratory manager serves as the portal of the Cyber Laboratory. After usual login, and VPN setups, it handles each student's VM allocation, which can be done through "dashboard". As it shows current actual and remote laboratory work-load status, students can easily select either actual or remote laboratories. Also, the user can ask the manager for the VM migration to/from actual/remote laboratories. Once the VM setup completed, the manager redirects the request to the designated VM/server. If the student's BYD is specified, the allocated VM performs not only usual experiment works but also performs the proxy services for the BYOD. The customized remote desktop/application or Web browser in the BYD will communicate with the proxy server in the VM. The course manager just set laboratory platform usage polices, according to the office-hours/ off-hours. The laboratory platform allocations can easily be realized by making use of available VM allocation software. The ratio of the actual/remote laboratory platforms can be adjusted according to the platform usage.

-CAD design file sharing among Private/Public cloud, faculty database and faculty educational system: In order to realize efficient sharing and transferring huge CAD data, the faculty database (file server) serves as a kind of cloud storage. As all the Web services send/receive only file IDs, an efficient data transferring can be achieved.

3 CYBER LABORATORY IN A HYBRID CLOUD ORGANIZATION

The proposed Cyber laboratory consists of On-Premise Private Cloud and the public cloud. Between two clouds, the Web services are employed as the communication means. It can combine the actual laboratory and the remote laboratory, with newly designed CAD services and FPGA-run services realized in the form of the Web Services. The faculty database plays an important role in Data sharing and synchronizations. It enables to share large experiment data among laboratory platforms, student/Teacher/TA PCs. As large CAD design files can become accessible from any PCs, the web services only need to transfer a few CAD parameters and the design file location IDs. Thus the file transfer overhead can be minimized. It is also useful for students, TAs and Teachers for further consultations and evaluations. Students can easily migrate from actual laboratory to remote laboratory and vice versa. And students can continue their projects at home, using their own PCs in almost the same environment as in the actual laboratory environment. Figure 2 show the private cloud system organization. For each laboratory experiment platform, which is one of the On-Premise private cloud components, a Web service virtual machine is allocated. It contains integrated FPGA tools, license Verilog-HDL synthesizer and the Web service server. The integrated FPGA tools accept the FPGA related Web services and perform device related tasks, such as FPGA Set-up/Run, logic-analyzer setup/run/get results. The Verilog-HDL logic synthesizer is the license software, encapsulated in the Web services. It accepts high-level descriptions and returns synthesized Verilog-HDL descriptions.

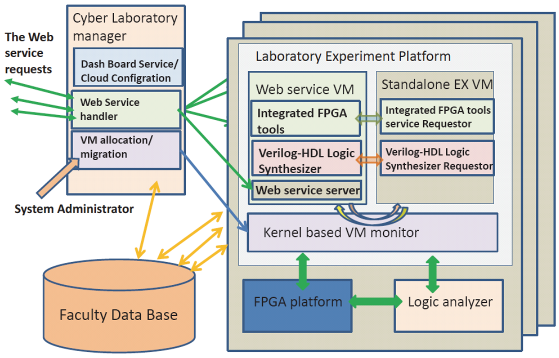

Figure 2: On-Premise Private Cloud System Organization.

The synthesizer is not a "must". Although students can do experiments without them, it can reduce significant amount of design works by combining high-level design and use of such logic synthesis tools. The synthesizer is not affordable to install all students' laptop or public cloud computers. So, the license software are only installed in the On-Premise private cloud laboratory platforms and the limited number of the public cloud computers. By preparing the Web services for the logic synthesis, students who want to use this functionality, can use them from remote site.

In the case of actual laboratory mode, student virtual machines are also set up on the corresponding laboratory platforms. The virtual network switch allows rapid inter virtual machine connections, as they reside on the same computer and messages do not go out of the computer. In this way, plural students' experiments can be carried out concurrently, by sharing FPGA and logic analyzer devices, even in the actual laboratory.

The cyber laboratory manager performs the system management tasks, such as student login/logout, VM allocations/migration, experiment platform allocations in On-Premise private cloud and the public cloud setups. The course manager set the policy to the cyber laboratory manager, and the rest of works can be done in self serviced fashions. The dash board service lets students to know current workload status and to select available platforms.

Figure 3 shows the public cloud side virtual machine organization. After the public cloud setup is completed, physical servers become available. The limited number of them should be assigned to run the logic synthesis virtual machines. Remaining servers are pooled for the use of student virtual machines. The purpose of the logic synthesis VMs is to offload the logic synthesis works from the laboratory platforms and to run the services in the public cloud. As the license limits the number of VMs, student VMs have to be installed the integrated FPGA tools without license Verilog-HDL synthesis tool and FPGA setup/RUN tools. Those removed tools are replaced with the corresponding Web services.

The logic synthesis VM organization is rather simple. It accepts the logic synthesis Web service requests, these are generated from other student VMs. In order to get/set the Verilog-HDL descriptions, the FTP is setup with the faculty data base (Experiment Data server).

Each Student VM handles the remaining laboratory works, except the device related services and the license Verilog-HDL synthesis. The student VMs generate corresponding Web services and send them to the designated VMs: Logic synthesis VMs in the same public cloud or the Web service VMs in the On-Premise Cloud via the internet. Another student VM's role is to act as the proxy for the student. If the student specifies the use of BYOD, then BYOD Proxy establishes the connection with the BYOD, via the remote desktop, BYOD application or Http.

The Figure 4 shows the experiment flows in actual and remote laboratories. For each student, a student virtual machine is allocated. By allocating

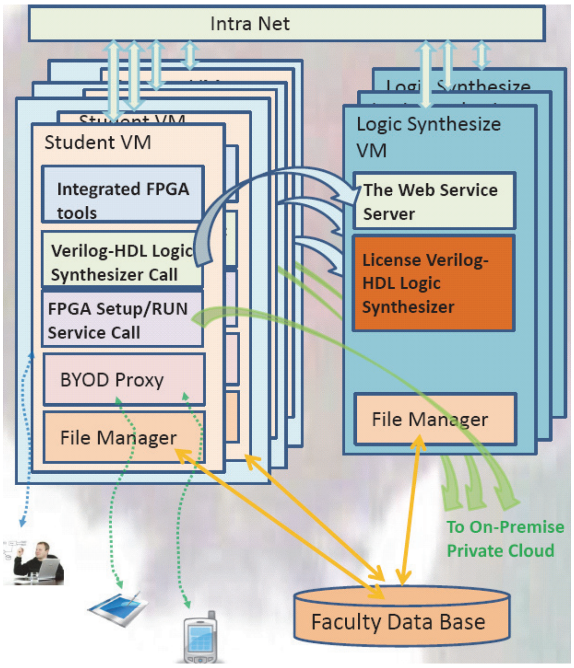

Figure 3: Public Cloud Side Virtual Machine Organization.

the student VM in the same laboratory platform as the Web Service VM, the actual laboratory environment is realized. All design stage works are carried out within the same platform.

In case of the remote laboratory mode, the student VM is allocated in one of servers in the public cloud. If the FPGA run is requested, the student VM setups the connection with one of the FPGA Web service VM in the On-Premise private cloud to do the FPGA run.

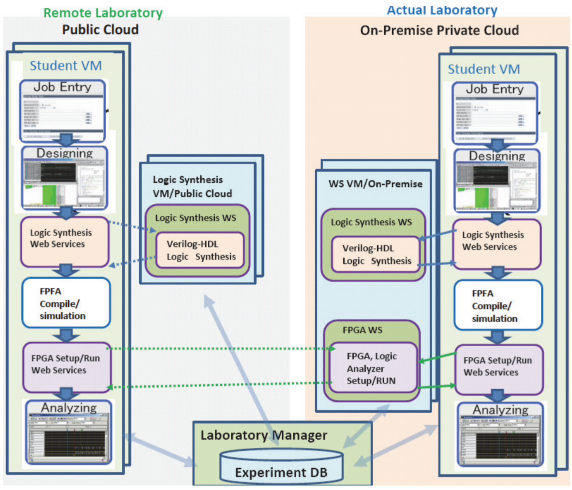

Figure 4: Experiment Flows in remote and actual laboratories.

In case of the logic synthesis request is issued, the student VM setups with one of the logic synthesis VMs in the public cloud. The corresponding logic synthesis Web services connect VMs via the public cloud intra-net. In this way, almost the same experiment environment can be realized both in actual and remote laboratory modes.

4 CONCLUSIONS

The Cyber laboratory in a hybrid cloud project combines the actual laboratory and the remote laboratory in a seamless way. It gives remote users real life experiences in hardware logic design and implementations. The device related services are handled by one of laboratory platforms as a private cloud.

The remaining non-device-related tasks are handled by student virtual machines in the public cloud. It can still exploit student side PC powers to offload platform workloads, if high-end PCs are available. In case when a student should login through a BOYD, a virtual machine in the public cloud is allocated and it serves as a proxy. The use of available cloud computing system tools contributed to reduce system developments works as well as system management/operation works.

The use of the experiment server as a Web storage contributed to realize a seamless migration between remote and actual laboratories. It also made it possible to share experiment data among students, TAs and teachers for further consultations. So, a flexible and scalable Cyber Laboratory, which can reduce the TCO, can be realized.

The project is just started and it is rather early to evaluate the effectiveness of the proposed system, but the author believes its success. The remaining problem is how to decouple the hardware integrated software, and to combine public cloud computing environments.

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Improving the Usability of Manga-on-a-Tablet for Collaborative Learning

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Keywords: Tablet PC, Annotation, Manga, Collaborative Learning, Teacher Education.

Abstract: The purpose of this study was to develop a tablet PC version of a system that promotes the learning of knowledge and skills related to science teaching, and to investigate its effectiveness. The characteristic feature of this system is that it supports collaborative learning through discussions based on case method materials by a manga (comic strip). The system makes students read scenes of a children's experiment displayed on the screen in the form of a manga. Touch operations on parts of interest enable students to point pins. Pins are color-coded in four colors. Students use the share functions to share awareness with each other and hold discussions to solve problems. We conducted an experimental evaluation with university students who intended to become elementary school teachers. The evaluation showed that the proposed system is effective in promoting discussion through the sharing of awareness.

1 INTRODUCTION

Fostering the talents and abilities of teachers and enhancing their expertise are currently recognized as key issues in teacher training. The pedagogical content knowledge (PCK) approach to teacher talent and ability promoted by Shulman (1987) is widely known (e.g., Gess-Newsome and Lederman, 1999; Mishra and Koeher, 2006). PCK is undoubtedly knowledge that is linked directly to the practical ability and expertise of teachers. With many of Japan's experienced teachers now approaching retirement, the country faces the issue of how to pass on the knowledge and skills of these teachers to their successors. The field of science education focuses on acquired knowledge and skills related to experimental equipment and teaching materials, but a sufficient number of teacher education materials have not been developed to enable young teachers and teaching-track university students to acquire such knowledge and skills.

Daikoku et al. (2013) responded to this problem by developing a tablet PC–based pilot version of case method materials that uses a manga designed to enable teaching-track university students to gain the knowledge and skills required for guiding students through experiments in science classes.

Manga is a familiar medium to young people; it enables stories to be read and understood relatively quickly, and can provide the information that students need to get in a focused manners. Tablet PCs can draw on these characteristics of manga to provide texts in a simple format. Further, since tablet PCs can communicate with each other to enable information sharing, they can provide a collaborative learning environment (e.g., Kim et al., 2009; Reid and Ostashewski, 2011). Using these texts, students read a manga depicting scenes of a science experiment conducted in the elementary school. They can append markers to each scene, share and discuss them with other students, and collaboratively learn the knowledge and skills required of elementary school teachers. However, the pilot version of this system only provided some functions for indicating and sharing awareness. For example, there were no functions for identifying who entered a marker or for seeing the entire manga in the list format.

To overcome these shortcomings, in this study, we developed a system that added the name display capability to the function for sharing awareness, and included a manga and pin list function. We also conducted an experimental evaluation of the system with teaching-track university students. The study's aim was to verify the system's operation and its effectiveness in promoting discussion among the users through the sharing of awareness.

2 SYSTEM OVERVIEW

2.1 Development Environment

The tablet PC development environment was Adobe Flash Professional CS6, enabling the system to be published as applications for iOS and Android. The server development environment consisted of Windows 7 (Professional) , Apache 2.2, PHP 5.3, and MySQL 5.5. The system can be operated on other operating systems if an equivalent service can be used.

2.2 System Configuration

Figure 1 shows the system configuration. The diagram only shows one tablet PC, but naturally, multiple tablet PCs are connected to the server, enabling the sharing of the entered pins and other data. After logging into the system from a client tablet PC, the user can view any manga page and use functions such as the pin entry function on any manga frame location at which the user wants to flag a problem. The information for these operations is sent over the network to the server and stored in a MySQL database through a control unit on PHP. When the "show others' pins" message is sent from a tablet PC, the information for all the pins entered in the manga being viewed is read from the MySQL database and returned to the tablet PC. The pins are then displayed on the tablet PC. In this way, students can share pins indicating awareness.

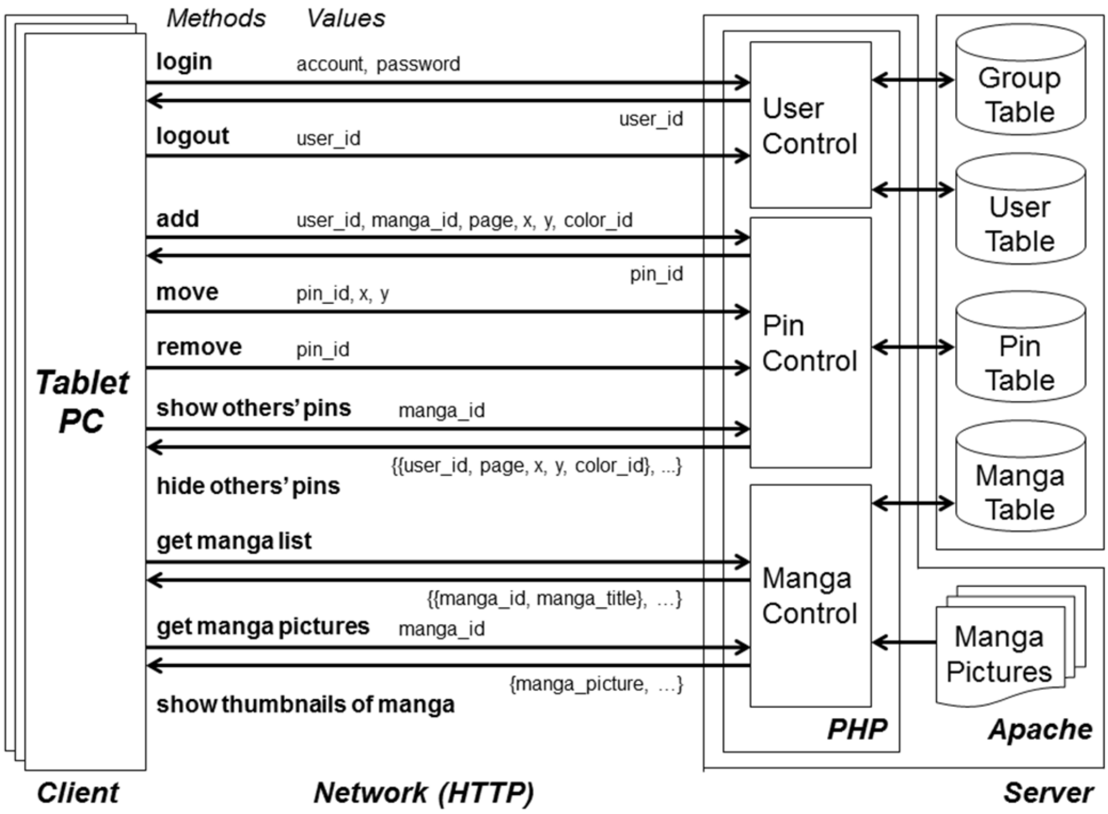

Figure 1: System Configuration.

2.3 Functions

Figure 2 shows the picture of the manga after logging in. In the diagram, awareness of individuals has been entered using the pin entry function.

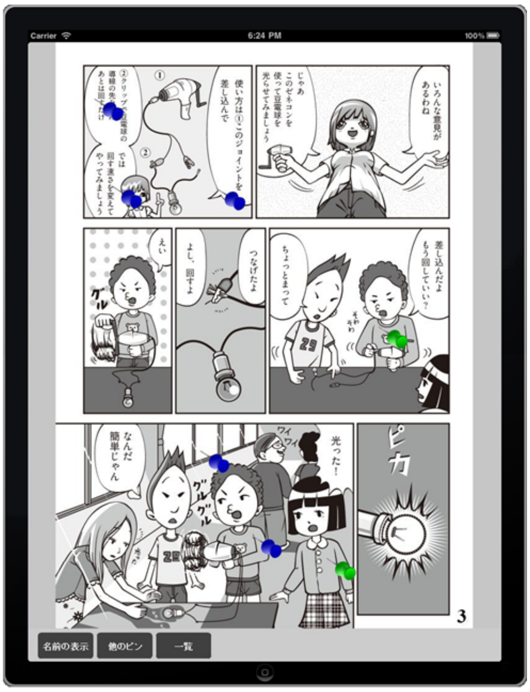

Figure 2: The picture of the manga after pin entry.

2.3.1 Manga Page Operation Functions

As with e-books for standard tablet terminals, swiping the manga to the right moves forward a page, while swiping it to the left moves back a page.

2.3.2 Pin Entry Function

Figure 3 shows the pin entry function. To enter a pin, the user touches the desired location (any location) in a manga for less than 1 s. The panel appears, containing pins of four colors (blue, green, yellow, and red). The user touches the pin of the desired color to enter it. Pins can be entered in a manga in this way to add annotations. Four colors of pins have been provided to enable students to color-code different categories of pin comments. Providing a meaning to each pin color clarified what each student focused on at each pin location. Pins in a manga can be moved by dragging them. Touching a pin for less than 1 s displays the panel. The user can then touch a pin of another color to switch the selected pin to that color. Touching the trash can delete the selected pin.

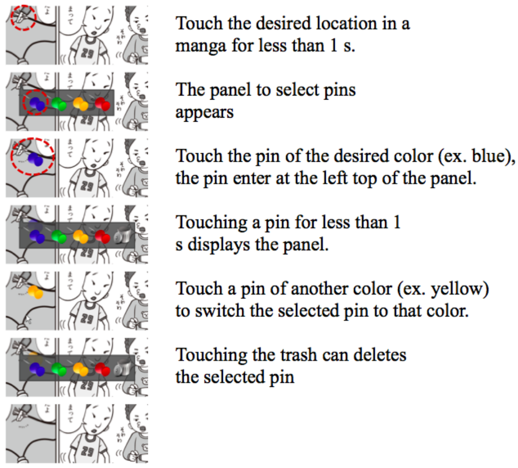

Figure 3: Pin entry function.

2.3.3 Manga Page Operation Functions

As with e-books for standard tablet terminals, swiping the manga to the right moves forward a page, while swiping it to the left moves back a page.

2.3.4 Functions for Sharing Awareness

As shown in Figure 4, touching the “Other pins” button at the bottom of the picture of the system makes the display of pins added by other students on the same page translucent, enabling the sharing of awareness. As shown in Figure 5, touching the “Display names” button displays the name of the student who entered each pin at the right of the pin. The names of other students are translucent like pin.

These operations enable the sharing of pin comments among students. Paying attention to pin input locations and color movement could be expected to promote discussion activities.

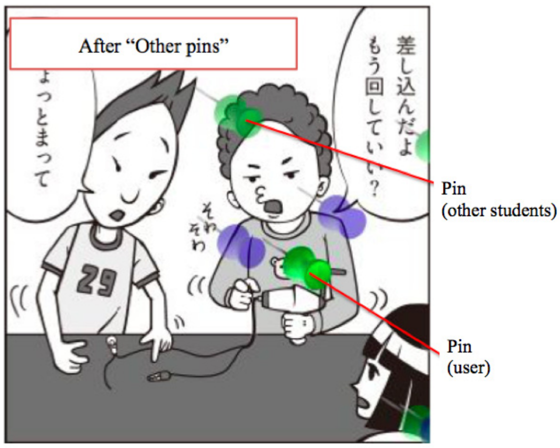

Figure 4: One scene of the manga after pin awareness sharing operation.

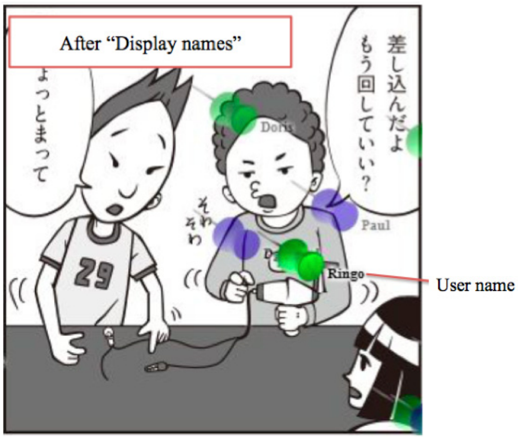

Figure 5: One scene of the manga after the display of names operation.

2.3.5 Manga and Pin List Function

As shown in Figure 6, touching the “List” button at the bottom of the picture of the system displays all the pages of the manga as thumbnails along with the entered pins. This function shows at a glance where comments have been entered throughout the entire manga along with the number of comments entered. Touching a thumbnail displays the selected page in the normal size.

In this way, the system enables the adding and sharing of noteworthy locations in various categories by means of pins in four colors, using only touch and gesture operations. It makes ample use of the convenience of tablet PCs.

Figure 6: The picture of the system using manga and pin list function.

3 EVALUATION EXPERIMENT

3.1 Evaluation Design

Purpose: To investigate the system’s operation and the effectiveness of discussions based on the sharing of awareness.

Participants: 32 university students planning to become elementary school teachers (13 men and 19 women). Participants were divided at random into groups of 4, for a total of 8 groups.

Procedure: Each group of participants took part in case method materials trial on tablet PCs. The procedure used was as follows: The participants first read the 8-page manga individually. Then, they entered pins for issues that they considered to be problematic in the story conveyed by the manga (for example, insufficient teacher guidance, broken equipment due to children’s misbehaviour, or a classroom environment unsuitable for the experiment). Finally, each group shared the pins entered by its members and held a discussion on the basis of these pins. After the case method materials trial, the participants evaluated the system by using the questionnaire method.

Evaluation items: There were two categories of evaluation items—items about the system’s usage and operation, and items about the sharing of awareness about manga frames. There were 13 items about the system’s usage and operation. They covered areas such as manga visibility, page operation, and commenting operations. Some examples of these items are as follows: “Picture of manga after pin awareness sharing operation was easy to view” and “Manga viewing operations were easy.” There were 9 questions about awareness sharing. They covered the discussion held on the basis of the shared awareness; e.g., “Sharing enabled us to discover differences in awareness about manga frames” and “When sharing, it was easy to distinguish my own pins from other people’s.” There were 22 items in all. For each item, the respondents selected a number between 1 and 5, with 5 representing “Strongly agree” and 1 representing “Strongly disagree.”
Survey period: October 3 to 21 2013

3.2 Results

Table 1 presents a tally of the responses received for the usage and operation items and a compilation of the results. The responses received for each item were classified into positive responses and neutral/negative responses. In particular, the

Table 1: Questionnaire survey results of the usage and operation.

Items	1	2
1. Picture of manga after pin awareness sharing operation was easy to view **	31	1
2. I carefully considered problems in the children's experiment while viewing the sharing system **	29	3
3. Operations for viewing the manga were easy **	26	6
4. It was easy to find the desired manga pages and frames **	27	5
5. It was easy to color-code problem importance levels by pin color *	19	13
6. The pin entry operation was easy n.s.	14	18
7. The operation for discarding entered pins was easy *	18	14
8. The operation for changing the color (importance level) of the entered pins was easy *	19	13
9. Pin awareness sharing operations were easy **	28	4
10. Picture of manga after pin awareness sharing operation were easy to view **	26	6
11. When using pin awareness sharing operation, important scene search operations were easy **	28	4
12. It was easy to distinguish other people's pins from my own **	21	11
13. It was easy to count the number of entered pins **	28	4

N=32 $^{**}p$<.01, $^{*}p$<.05, $^{n.s.}$not significant 1: Positive answer, 2: Neutral and Negative answer

participants responding with a 5 or 4 were classified as positive respondents; participants responding with a 3, 2, or 1 were classified as negative respondents; and the number of each type of respondents was tallied. We determined the statistical significance of the deviation between the number of positive respondents and that of the neutral/negative respondents by using a 1 × 2 exact test.

The results showed no statistically significant difference between the number of positive respondents and the number of neutral/negative respondents for one item (Item 6: Pin awareness sharing operations were easy). The number of positive responses trended higher for three items (Item 5: It was easy to color-code problem importance levels by pin color, Item 7: The operation for discarding entered pins was easy, and Item 8: The operation for changing the color (importance level) of entered pins was easy), with the difference between the number of positive respondents and the number of neutral/negative respondents being statistically significant at the 5% significance level. For each of the other 11 items, the number of positive responses trended higher, with the difference between the number of positive respondents and the number of neutral/negative respondents being statistically significant at the 1% significance level.

Table 2 presents a tally of the responses received for the items about sharing of awareness about manga frames and a compilation of the results. We analysed the results using the same procedure used for the usage and operation items, determining the statistical significance of the deviation between the number of positive respondents and that of neutral/negative by using a 1 × 2 exact test.

As a result, for each of the 9 items (such as Item 14: Sharing awareness enabled us to discover differences in awareness about manga frames and Item 20: Sharing awareness enabled a lively discussion in the group), the number of positive responses trended higher, with the difference between the number of positive respondents and the number of neutral/negative respondents being statistically significant at the 1% significance level.

4 CONCLUSIONS

The experimental evaluation results demonstrated the following two points: (1) The system's interface has effective operation. (2) The system effectively promotes discussion based on shared awareness about manga frames.

However, there is a need to improve the convenience of the interface for the pin entry, movement, and erasing functions. Specific changes could include improving the response and mounting a continuous operation method enabling flick-based pin color selection and changes.

ACKNOWLEDGEMENTS

This research was supported in part by the Grants-in-Aid for Scientific Research (A) (No. 24240100) and JSPS the Grants-in-Aid for Scientific Research (B) (No. 24330251).

Table 2: Questionnaire survey results of the sharing pin awareness about manga frames.

Items	1	2
14. Sharing awareness enabled us to discover differences in awareness about manga frames **	31	1
15. When sharing, it was easy to distinguish my own pins from other people's **	23	9
16. Sharing awareness enabled us to discover differences in reasons for awareness about frames **	29	3
17. It was easy to find manga frames in which many pins of the same color had been entered **	31	1
18. It was easy to find locations where pins of different colors had been entered in the same frame **	29	3
19. It was easy to decide on which manga frames to discuss **	21	11
20. Sharing awareness enabled a lively discussion in the group **	28	4
21.Simultaneous sharing awareness and discussion enabled a good understanding of other people's opinions **	30	2
22. Simultaneous sharing awareness and discussion enabled explanations that were easy to understand **	29	3

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The Virtual Design Workshop
An Online Adaptive Resource for Teaching Design in Engineering

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Keywords: Engineering Design, Adaptive Tutorials, eLearning.

Abstract: Design education aims to develop in students the confidence to apply engineering fundamentals to the design of products and systems. This can only be achieved through intensive education and exposure to real-life engineering problems. One of the pressing issues in teaching engineering design is the resources- and labour-intensive nature of the subject. In practice, when developing a design, engineers are dependent on the situation at hand, so goals, problems and constraints are often ill defined and may change as the problem continues to unfold, providing no single ideal solution. Assumptions and estimations are required before each analysis step, and the results need to be evaluated against the desired functional output. Often, many analysis iterations are needed before a suitable solution is found. When teaching, providing the same scenario requires that tutorial guidance must adapt to the particular solution of each individual student. Conventional online tutorials help to combat some issues, but they are not able to track student progress in detail, nor are they able to provide customisable feedback for individual students. The aim of the research is to develop software tools that can address key problems in engineering design education and provide students with a more effective and enriching educational experience. This paper discusses a response to the issues in design education in engineering, in the form of adaptive tutorials, and puts forward the preliminary analysis of their success in helping students overcome the limitations of current design education.

1 INTRODUCTION

Design is an essential component of any engineering discipline, a combination of technical expertise and creativity. Good design is vital in creating objects and spaces that work. Design is widely considered to be at the core of engineering and it is well established that "…engineering programs should graduate engineers who can design effective solutions to meet social needs…" (Dym et al., 2005). Engineering science education tends to focus on developing skillsets within students, which allow them to solve particular problems in particular ways. The skills and knowledge build hierarchically on what was previously learnt. Often many previously learned concepts and capabilities need to be employed in order overcome the challenges in the problem to find a solution. It misleadingly implies that there is an ideal approach to the problem and an ideal solution. In reality, few true engineering problems fit this model. In practice, when developing a design, engineers are dependent on the situation at hand, so goals, problems and constraints are often ill defined and may change as the problem continues to unfold (Lemons et al., 2010). There is no single ideal solution in this situation. Assumptions and estimations are required before each analysis step, and the results need to be evaluated against the desired functional output. Often, many analysis iterations are required before a suitable solution is found. Although engineers often have general guidelines for the design process, there is no consensus regarding one correct procedure to follow in order to reach a solution (Lemons et al., 2010).

Students are often uncomfortable with the notion that there is no correct answer, as the majority of their prior learning has been assessed with examinations and quizzes where there are definitively correct answers (Goldsmith et al., 2010). Many initiatives have been taken to identify the reasons for poor student engagement with engineering design and to find ways to address the problem, both by individual teachers and, increasingly, by the community of engineering academics. The problem may lie in graduate students' capability to find solutions to previously unseen problems. A theoretical position on this capability and threshold concepts has been proposed in a recent paper by (Baillie et al., 2013). Numerous efforts have also been made to better integrate design into engineering curricula (Carroll, 1997; Kartam, 1998; Kurfess, 2003) and prepare graduate engineers for the industry (Todd et al., 1995). Ultimately, engineering design seeks to find a technical solution that best satisfies a particular set of requirements. This design process takes into account a range of factors, including economics, buildability, sustainability, technical performance and safety, but it is largely driven by the requirements of the problem space.

2 BACKGROUND

Despite incorporating long-practiced teaching and learning approaches for engineering design courses, current methodologies still suffer from inherent shortcomings. Design courses are resource intensive. With each passing year, there is a trend toward resources to teach becoming more limited despite increasing student enrolments, making authentic design experiences difficult to achieve (Dougherty & Parfitt, 2009). This is further exacerbated by the inability to provide feedback to such a large number of students in a timely and efficient manner. Traditional design teaching (workshops, studios, laboratories, etc.) does not translate well spatially or temporally. The interactivity of design teaching requires students to be located in the same time and place as the teacher. This limits opportunities for distance education (MOOCs) and also limits a student's capability to learn at an individual pace. Furthermore, it can be difficult to evaluate student performance in complex design assignments due to the variability of student responses. This problem is exacerbated when students work in teams, as accurate evaluation based on individual effort is difficult to implement (Dutson et al., 1997). Design courses require lecturers to put extra time into devising suitable projects for students, looking for suitable industry-sponsored projects, and coordinating the course itself (Todd et al., 1995; Wilczynski & Douglas, 1995). Faculty members have limited professional and industrial experience in design disciplines (Dutson et al., 1997). The reason for this could be today's increased focus on research output. An increasing proportion of faculty staff are recruited directly upon the completion of a fruitful post-doctoral period – staff with little, if any, professional industrial design experience.

Two particularly effective educational frameworks already integrated into engineering design education are "project-based learning" and "problem-based learning". Generally, project-based learning is directed at the application of knowledge in projects, whereas problem-based learning involves the acquisition of knowledge and skills in the process of solving previously unseen problems (Heywood, 2005; Perrenet et al., 2000). These two approaches are similar in that they focus on student learning rather than teaching (Kolmos, 1996). They are also similar to providing students with many worked out problems and their solutions, another effective means of improving problem solving (Sweller & Cooper, 1985). However, current project/problem/studio-based learning (PBL) and teaching methods have proven very costly to run. This cost arises because typical hands-on projects or design assignments in physical laboratories, workshops and studios require space, logistics, equipment, time and money, which are traditionally limited resources. Consequently, the extent to which these teaching methods can be utilised is restricted, often to cornerstone design courses (e.g. ENGG1000 at UNSW). With ever increasing enrolment numbers, the sustainability of even these major hands-on courses is under threat. PBL curricula are also difficult to scale to very large classes or to move online (MOOC) due to the substantial requirement for students to physically attend laboratories and work on projects collaboratively. There thus exists a need for complementary tools to augment existing design education in the online space. These tools need to replicate, as closely as possible, authentic design experiences and surround students in the design ethos. A number of software solutions are currently on the market for the purpose of teaching design-based engineering subjects.

Gibson et al. (2002) evaluated a software package, Design Builder, based on its content, operational measures, technical ability and feedback and assessment. They found that Design Builder scored extremely well under all the headings, in particular scoring above 90% in its Feedback and Assessment section, concluding that the program has achieved its goals in teaching students. The article (Gibson et al., 2002) goes on to recommend that Design Builder be adopted as an aid in teaching engineering design at the undergraduate level. One of the main benefits of Design Builder, and its potential success as an aid in teaching the concepts of design, is the ability to easily portray the practical application of the problem before design can commence. The software also allows students some control over specific variables of their design, allowing them to see first hand the effects of practical applications of the design. However, the limited control does not allow students to effectively evaluate the different characteristics of design of the system, and therefore does not provide feedback on all aspects of system design.

An additional software package (unnamed) that can aid in learning, allows the student to explore elements of shaft design (Álvarez-Caldas et al., 2007). The software provides the student design with a high degree of control, allowing changes to the overall structure and also the specific variables of design. This is an advantage to learning, as students are given the opportunity to see what effect specific variables and elements have on the overall design of a shaft and can be provided with detailed feedback relating to each of the elements.

The objective of the Heat Exchanger package (Tan & Fok, 2006) is to educate the student in heat exchanger design, and to "…bridge the gap between theoretical consideration and engineering practice…" (Tan & Fok, 2006) The software allows the students to become acquainted with heat exchanger designs through thermo-hydraulic analysis, and to understand the fabrication, costing and maintenance aspects of the design through its mechanical drawings. The program provides the student with control over specific variables that influence the overall design and also provides a customized overview of the design, however, it lacks the mechanical design capabilities for the students to understand the practical engineering application of the final design (Tan & Fok, 2006). Furthermore, other limitations of the Heat Exchanger software are that feedback is not instantaneous, and an academic is not easily able to see the progress of the students.

West Point Bridge Design (WPBD) is a nationwide competition organized by the United States Military Academy (USMA) (Symans, 2000; Ressler & Ressler, 2004). The competition is aimed at increasing interest in engineering among middle and high school students, by allowing them to engineer a solution to a real-world problem. The WPBD software provides the tools that students need to design and create a steel highway bridge, based on real-life parameters. This allows students to learn more about engineering design, by applying mathematics, science and technology principles to create a device that will service human needs. Students are required to use the WPBD software to design a bridge based on the specified criteria and constraints. The WPBD software allows students to graphically create a structural design, in which the student chooses the material and mechanical properties of each structural member. The student is then able to run a simulated load, determining the ability of the bridge to carry a specified load. Creating a successful design with this software is fairly simple; however, creating an optimal design at the lowest possible cost is the real challenge, thereby replicating a real-world situation (S. J. Ressler & E. K. Ressler, 2004). The target audience of this competition is limited to high school students and there is no direct educator feedback. This is strictly a design competition, so whilst it is effective in demonstrating some of the elements of design, it is not effective in teaching, or providing information to improve future design decisions. Students are required to conduct outside research that they can then use to design and test a bridge. Specifically, a survey conducted by Ressler et al. (2004) found that whilst students demonstrated a high level of perceived learning about structures, they demonstrated a relatively lower levels of learning about engineering design.

Design teaching initiatives have also been implemented by Khan Academy (*www. khanacademy.org*). One of the biggest advantages of the Khan Academy resources is its ability for students to progress at their own pace, with feedback provided as needed, ensuring individualised learning. Perhaps, the most unique thing about Khan Academy is the incredibly reach that it has. Globally, in 2012, the site was used by approximately 6 million unique students each month (Noer, 2012). Whilst the benefits of the Khan Academy cannot be denied, the setback to this mode of learning is the lack of guidance from an educator, when it is required.

The University of Pennsylvania has also undertaken an online design course. Web-based learning technologies including student generated electronic portfolios, an e-studio website and asynchronous discussion board technologies were implemented and tested throughout a multiphase research study. The study was constructed as part of curriculum improvement activities for the capstone design course sequence in the Department of Architectural Engineering. A major part of the Capstone design program is the e-studio practitioner mentorship program, providing online access to staff members who are experts in the student's field of study. The use of web-based technology has proven a success, and has provided improved course management, enhanced practice-based course content, increased visibility of student-generated projects and improved student/practitioner interaction (Dougherty & Parfitt, 2006).

One of the issues with current software-based design education is the inability to provide feedback and to engage in discussion with students. The need to address these issues are seen in such packages as Khan Academy Online, Pennsylvania Capstone Design and Udacity Online, which provide the students with a discussion forum aimed at improving learning and understanding. A proposed solution to the current issues faced in engineering design is the use of adaptive tutorials (Ben-Naim et al., 2008), where interactive instructions are adapted to student's level of understanding. Online Adaptive Tutorials (ATs), already well established in engineering science courses, promise particular benefits for design education. Similarly, they have been successfully trialed in other domains such as medicine (Velan et al., 2009). AT's have been shown to help overcome the constraints of limited resources while providing students with improved and personalised support when and where they want it. Engineering design problems present imperfect input information and have no predefined result. Each student must devise their own solution to each design problem they face. The problem factors to be analysed during the design process are difficult to specify at the outset, meaning that the tutorial guidance must adapt to the particular solution that each individual student devises. Adaptive tutorials provide a complete feedback loop to the students. They are designed so that a student is able to interact with a simulation whilst being guided, and given unique feedback based on student input into the system (Marcus et al., 2011; Prusty, et al., 2011b; Prusty, 2011; Prusty & Russell, 2011; Prusty, Ben-Naim, et al., 2011a; Ben-Naim & Prusty, 2010; Prusty, 2010). This can allow for customised student learning and real-time feedback for educators from a large group of students, thereby reducing the load on the educator and minimising course resources. The educator receives feedback on student learning via the Solution Trace Graph (STG), a visual summary of overall student performance, and can use this to update and modify instructional content as needed (Ben-Naim et al., 2009) (Figure 1).

An increasing enrolment base of students restricts the courses that can be run due to the physical space and physical equipment restrictions that come with large group sizes. Thus exists a need for complementary tools, such as adaptive tutorials to augment existing design education in the online space. These tools need to replicate, as closely as possible, authentic design experiences and surround

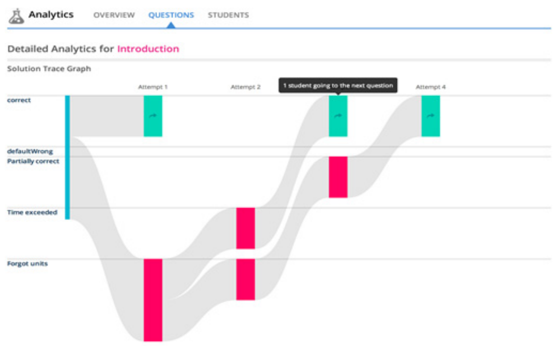

Figure 1: An example of a Solution Trace Graph.

students in the design philosophy that will ensure a future generation of engineers capable of approaching a range of different problem spaces and solutions.

2 PILOT STUDY

This pilot study used the Adaptive Tutorial system pioneered at The University of New South Wales (UNSW) (Ben-Naim et al., 2008; Prusty, et al., 2011b; Prusty et al., 2009; Prusty et al., 2013). Adaptive Tutorials (ATs) are web-based, intelligent and interactive eLearning tools, implemented on an Adaptive eLearning Platform (AeLP). ATs have been implemented since 2006 at UNSW and various other international universities in science-based education. Prusty and his colleagues (Prusty et al., 2013) have found adaptive tutorials to be effective tools in teaching science-based engineering subjects. ATs supply a valuable teaching tool with the possibility of providing a highly customised learning environment for each student (Khawaja et al., 2013). There are two features in particular that make the application of adaptive tutorials suitable to design instruction. Firstly, the visual and interactive capabilities of the AeLP offer a virtual environment with interactive tools to better engage students in engineering design. And secondly, the Adaptive Tutorial provides timely feedback, tailored to each student's actions and responses. This provides students with improved and personalised support when and where they need it – vital elements for effective design education.

The Design Adaptive Tutorial was implemented as a learning and assessment exercise to help students understand the fundamentals of design in the Solid Mechanics course offered at the second year level at the University of New South Wales (Figure 2).

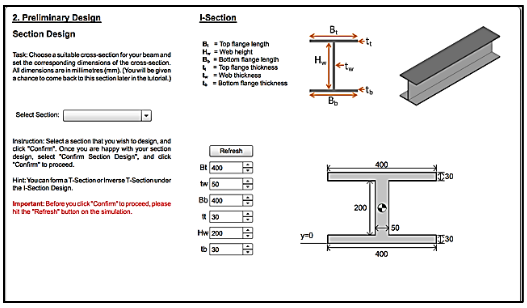

Figure 2: A screenshot from gantry beam design AT.

The tutorial was implemented for the last two years, in 2012 and 2013. Qualitative analysis of student feedback was undertaken in the form of a questionnaire based on student experience with Adaptive Tutorials in Semester 1 in 2013. In total, 304 students attempted the tutorial with an average mark of 92% scored in the tutorial material.

3 RESULTS AND DISCUSSION

A survey was given to 304 students with questions gauging the effectiveness of the adaptive tutorial in learning the concepts for the mechanical design of a gantry beam (Figure 3).

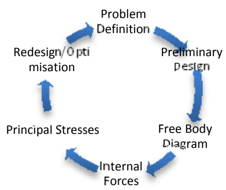

Figure 3: Design Loop for a gantry beam using Solid Mechanics fundamentals.

A number of students commented on the effectiveness of immediate feedback mechanism, as one of their most important learning resources, to the question “Do you find this Adaptive Tutorial useful to apply the fundamentals of Solid Mechanics?” Immediate feedback provided students with the ability to complete the tutorial and learn at an individual pace suitable to the student’s learning needs. Table 1 documents the identified themes taken from students commenting in response to the survey question on whether the AT was useful is applying the fundamentals of Solid Mechanics.

The vast majority of students found the tutorial to be helpful in applying fundamental principles, and 82% indicated that the tutorial was indeed useful to apply principles of Solid Mechanics (Figure 4).

Table 1: Identified themes from student comments on the usefulness of the AT to the fundamentals of Solid Mechanics.

Theme	*Comments No*
Helpful	41
Instant feedback	37
More interactive than classroom learning	29
Revision of basic concepts	15
Incorporates many necessary fundamentals	13
Shows design process in action	13
Enjoyable experience	11
Applicable to current study	9
Step by step	7
Not sure if useful to me	2

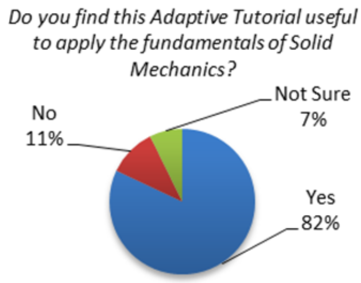

Figure 4: Applying ATs to the fundamentals of Solid Mechanics course.

More importantly, it appears that students found it easy to navigate their way through the adaptive tutorial and found the tutorials to be easy to learn

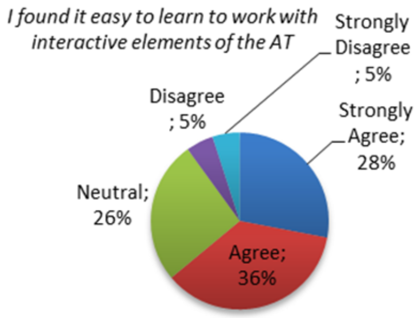

Figure 5: Ease of use of AT interactive elements.

(Figure 5). A number of students also commented on the ease with which they were able to manipulate the interactive elements of the tutorial, therefore using their limited cognitive resources to complete the tutorial as opposed to learning the tutorial interface.

A positive response was also obtained from students on the preference of using Adaptive Tutorial as a learning tool in Solid Mechanics (Figure 6). Approximately one third of the students surveyed, or 32%, strongly agreeing that Adaptive Tutorials are their preferred teaching method as opposed to traditional written assignments and 33% of students surveyed agreeing that adaptive tutorials are a preferred method of learning.

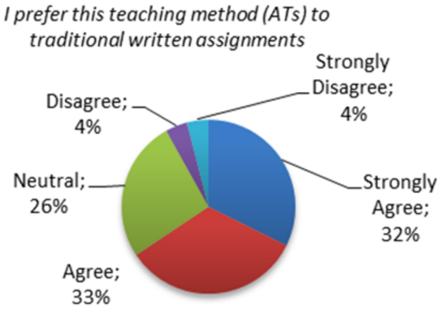

Figure 6: Preference for teaching methods.

4 CONCLUSIONS

The pilot study has indicated that adaptive tutorials could be an effective solution to design education in engineering. Adaptive tutorials enrich student knowledge with the instantaneous real-time and customised feedback, based on student input into the system. In particular, for larger groups of students, educators are able to instantly discern problems that a student might be experiencing with coursework material without the need for individual consultation via the STG, a visual summary of overall student performance. This can be used to update and modify instructional content as needed, thereby reducing the load on the educator and minimising course resources (Ben-Naim et al., 2009).

Furthermore, an increasing enrolment base of students restricts the courses that can be run due to the physical capacity and equipment restrictions that come with large group sizes. Thus exists a need for complementary tools, such as adaptive tutorials, to augment existing design education in the online space. These tools need to replicate, as closely as possible, authentic design experiences and support students with the development of design that will ensure a future generation of engineers capable of approaching a range of different problem spaces and solutions.

Leading on from the pilot, further studies will utilise not just qualitative survey data, but will also include information regarding course marks and overall course performance. The program of adaptive tutorials will also be expanded to encompass different engineering disciplines, such as Mechanical Engineering, Civil Engineering, Naval Architecture and Aerospace Engineering and also include Architectural design problems. This will aid in providing an overall picture into the effectiveness of adaptive tutorials in student understanding of fundamental design concepts in engineering.

ACKNOWLEDGEMENTS

This project is funded by the Office for Learning & Teaching, an initiative of the Australian Government Department of Education, Employment and Workplace Relations (Project OLT ID 13-2837).

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A Usability Evaluation of Graphical Modelling Languages for Authoring Adaptive 3D Virtual Learning Environments

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Keywords: Graphical Modelling Language, Domain Specific Modelling Language, Adaptivity, Virtual Reality, 3D Virtual Learning Environments.

Abstract: Adaptive three-dimensional (3D) Virtual Learning Environments (VLEs) offer many advantages for learning, but developing them is still far from easy and is usually only done by specialized people. However, involving teachers in the development of learning material is essential. One way to support teachers in authoring adaptive 3D VLEs is the use of domain specific modelling languages as such languages provide a high level of abstraction. In addition, graphical languages are recommended for non-technical users. Although such an approach, i.e. graphical domain specific modelling languages, seems to be promising there is a need for evaluating this in practice. Usability and acceptance could become a problem because the authoring process could become relatively complex. This paper reports on a pilot evaluation performed to evaluate the use of graphical modelling languages for designing (i.e. authoring) adaptive 3D VLEs.

1 INTRODUCTION

To come to effective and challenging adaptive Virtual Learning Environments (VLEs), it is essential to involve educators and experts in the subject domain, in the development of the VLE. However, developing a 3D VLE is still quite a technical issue, and adding adaptivity to such an environment does not make it easier. Supporting or involving educators in the development of adaptive 3D VLEs is still in its infancy. Therefore, this is a priority for our research.

In the context of educational games, it is already noted that involving educators in the development of educational 3D games can be achieved by providing user friendly, effective and efficient authoring tools (Overmars, 2004; Marchiori et al., 2011). This is also what we want to achieve for 3D VLEs. Therefore, we proposed a set of easy to use graphical Domain Specific Modelling Languages (DSMLs) for authoring adaptive 3D VLEs (Ewais and De Troyer, 2013).

The rationale behind using graphical languages is that graphical specifications are, in general, easier for the communication with non-technical people. They make it easy to convey information, as many people can think and remember things in term of pictures (Boshernitsan and Downes, 2004). Furthermore, they can provide appropriate abstractions that make the specifications easier (Moody, 2009). However, they should be defined with care to be usable and effective.

In general, DSMLs are languages that use a specific vocabulary dedicated to the modelling and designing a specific class of problems (Deursen et al., 2000). They are particular well suited for domain experts as they use the vocabulary of the domain rather than some general modelling language vocabulary. Mostly, DSMLs are graphical languages.

Giving due consideration to the usability of software is essential. Good usability provides different advantages: improved user satisfaction, increased usefulness and effectiveness, improved ease of learning and use, reduced training and support costs. Therefore, we conducted a pilot evaluation of the graphical DSMLs proposed for authoring adaptive 3D VLEs. The primary aim of the conducted evaluation was to reveal if we had chosen the right direction with these DSMLs and if they were usable for the task of specifying an adaptive storyline-based 3D VLEs.

Section 2 briefly describes the graphical languages. Section 4, 5 and 6 present respectively the evaluation and its results. Section 7 concludes the paper.

2 AUTHORING ADAPTIVE 3D VLE

Based on our previous work done in the context of the EU-project GRAPPLE (De Bra et al., 2010) and insight obtained from a literature review, we proposed a new approach for authoring adaptive 3D VLEs (Ewais and De Troyer, 2013). The kernel of the approach is a set of three DSMLs: one for expressing the pedagogical structure of the underlying learning domain (the Pedagogical Model Language), one to define the (adaptive) learning path (i.e. storyline) for the course (the Adaptive Storyline Language), and one for specifying the 3D adaptivity inside the different topics of the course (the Adaptive Topic Language). We described each language briefly.

The Pedagogical Model Language (PML)

To define the pedagogical structure of the adaptive 3D VLE, the authors can connect learning concepts (defined in the Domain Model[1]) via Pedagogical Relationships Types (PRTs) (see Figure 1).

A typical example of a PRT is the *prerequisite*. The goal of this PRT is to define when a learning concept is a prerequisite for another learning concept meaning that the learner needs to study the first concept before he can start learning second concept. Other possible PRTs are *Defines, Illustrates, Interest, Propagates_knowledge,* and *Update_knowledge*.

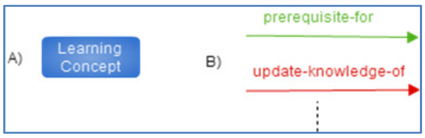

Figure 1: PML elements: A) learning concept B) Pedagogical Relationship Types (PRT).

The PRTs are associated with *Pedagogical Update Rules* (*PURs*), which are condition-action rules. This rule mechanism is used to define how the knowledge of the learner (kept in the User Model[2]) should be updated, i.e. a rule defines how and which User Model attributes should be updated. When the learner follows the course, the PUR of a PRT is triggered on accessing the source learning concepts of the PRT.

The general format for the PURs is as follows:

```
IF <user_model_condition>
THEN <user_model_update_actions>
```

Different PRTs are predefined. In general, the predefined PRTs and their associated update rules (PURs) are sufficient to accommodate common pedagogical relationships between learning concepts in different domains. However, authors can define new PRTs or change default PURs.

An example Pedagogical Model is given in Figure 2. The learning concept *Sun* is a prerequisite for the learning concepts *Mercury*, *Venus*, *Mars*, and *Earth*. The PUR associated with this *prerequisite-for* PRT is given in the callout symbol. Furthermore, when the learner learns about *Mercury*, his knowledge about *Venus* will also increase. This is specified in the PUR associated with the *update-knowledge-of* PRT between *Mercury* and *Venus*. This PRT is also applied to other concepts: *Venus*, *Mars*, and *Earth*.

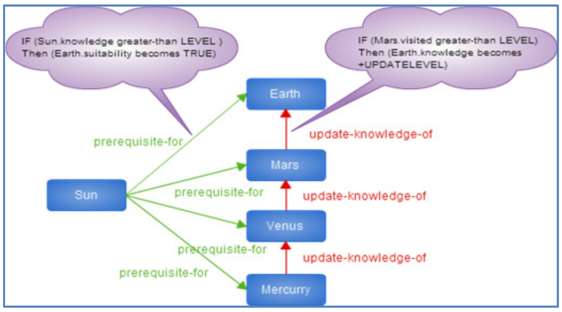

Figure 2: Pedagogical Model for a number of learning concepts related to a Solar System Course.

Adaptive StoryLine Language (ASLL)

This language allows defining a learning path inside a 3D VLE (i.e. storyline) by enables the authors to define a set of topics and connecting them. Next, the author can also indicate how this storyline should adapt to the individual learner.

Decomposing the storyline into different topics is used to reduce complexity. Topics can be compared to chapters in regular courses. To express the adaptivity of the storyline, each topic is connected with a next topic via a so-called Storyline Adaptation Rule. An example is given in Figure 4. Figure 3 shows the graphical notations of ASLL. Note that a storyline has a start and end. Start and end symbols (Figure 3 (A) and (F)) can be used to

[1] The Domain Model defines the learning concepts. It is outside the scope of this paper.
[2] The User Model is a typical model used in adaptive systems. It captures all information about the user, like preferences and his knowledge about the learning concepts.

specify the textual and/or audio/video messages to be presented to the learner at this point. Such messages can e.g., be used to instruct the learner what to do or what he achieved. Furthermore, for a Storyline Adaptation Rule (Figure 3 (C)) the arrow points from the source topic to the target topic. Rules should be given a meaningful name in order to increase the readability of the model.

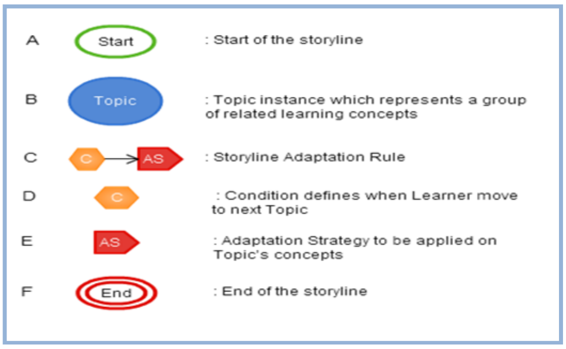

Figure 3: ASLL elements: A) Start of a storyline; B) Topic in a storyline; C) Topic Adaptation Rule; D) condition; E) Adaptation state; F) End of a storyline.

A Storyline Adaptation Rule is a condition-action rule. The condition (Figure 3 (D)) specifies when the learner can proceed from the source topic to the target topic, and is, in general, based on the learner's knowledge level about the source topic and the suitability of the target topic. The action part (Figure 3 (E)) is used to specify what kind of adaptation should be applied to the learning concepts involved in the target topic. Example adaptations are marking learning concepts with bounding boxes or annotations, hiding learning concepts, or providing a guided tour to the concepts related to the topic. Possible adaptation are predefined, see (De Troyer et al., 2010).

Figure 4 shows an example of an adaptive storyline for a course about the solar system. The storyline is composed of the topics: *Learning About Stars, Inner Solar System, Moons, Outer Solar System,* and *Advanced Topics*. The learner will start with a guided tour for the topic *Learning About Stars*. After acquiring the required knowledge for this topic, the learner will be directed to a new topic, either to the *Outer Solar System* or to the *Inner Solar System*, depending on the truth-values of the conditions associated with the two storyline adaptation rules. For instance, the storyline adaptation rule between *Learn About Stars* and *Inner Solar System*, is as follows:

IF 'Learn About Stars'.knowledge greater than 90
AND 'Inner Solar System'.suitability is TRUE
THEN APPLY 'markobject' **TO** 'Inner Solar System'

The rule states that if the learner's knowledge about topic *Learn About Stars* is above the specified value and the suitability of topic *Inner Solar System* is true, then the *markObjects* adaptation should be applied to the learning concepts of the *Inner Solar System* topic.

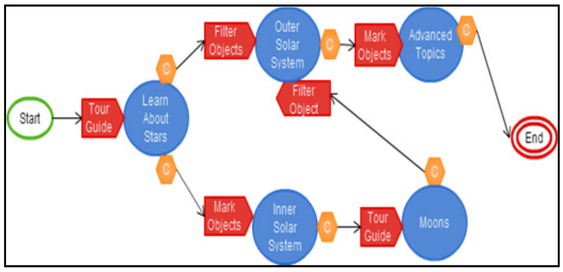

Figure 4: Adaptive Storyline for 3D VLE Solar System Course.

Adaptive Topic Language (ATL)
This language allows describing how the content related to each topic should be adapted to the individual learner, i.e. it allows specifying the adaptivity within a single topic. This is done by means of adaptation rules between learning concepts. The rules are event-condition-action rules. They are triggered by activities performed in the 3D VLE. Figure 5 shows the symbols used in ATL.

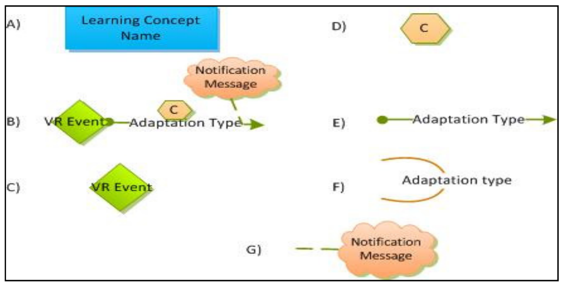

Figure 5: ATL elements: A) Learning concept, B) Adaptation rule, C) VR event, D) Condition, E) and F) Adaptation type to be applied to a 3D learning Concept, G) Notification Message.

A topic is composed of a set of learning concepts (Figure 5 (A)). Learning concepts are connected through so-called Topic Adaptation Rules. A topic Adaptation Rule (Figure 5 (B)) has a source (learning concept) and a target (learning concept). The event part of the rule (Figure 5 (C)) specifies the event that will trigger the rule. This event has to occur with the source. The rule will only be executed when the condition in the condition part (Figure 5 (D)) is true. The action part (Figure 5 (E) or (F)) specifies the adaptation to be applied on the target learning concept. Version (E) is used when source and target are different; version (F) when source and target are equal. Also a notification or feedback message to the learner can be specified (Figure 5 (G)). This message will be shown when an adaptation rule is applied. A set of predefined adaptation types is available (De Troyer et al., 2009). Figure 6 shows an example Topic Adaptation Rule. This rule will be fired once the learner "comes close to" (VR event) *Sun*. Next, the condition of the rule will be evaluated. Here, a test on how often the learner already interacted with *Sun*. If this is higher that the specified value, the action part is executed, i.e. *SemiDisplay* adaptation type will be applied to *Earth* to display *Earth* is a semi way.

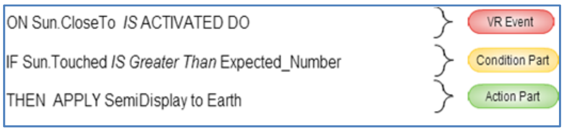

Figure 6: Example topic adaptation rule.

VR events are used to indicate when the adaptation rules should be evaluated. The VR events are events related to the learner's activities inside the 3D VLE, e.g., interaction with a 3D object or navigating to a 3D object. The condition must be satisfied in order to actually perform the action-part of the rule. The condition will in general deal with the learner's preferences, his learning background, and progress, but may also consider previous activities performed by the learner in the 3D VLE (captured by so-called 3D VLE activity history attributes). By including conditions on previous activities performed by the learner in the 3D VLE, the author is able to control the learner's behaviour in the 3D VLE, e.g., to avoid that the learner wastes too much time by playing around.

Two examples adaptation rules are given in Figure 7. The first adaptation rule (Figure 7(A)) is between two different learning concepts (*Sun* and *Earth*). The VR event *close to* will trigger the rule. When the rule is applied, the adaptation type *display* will be applied to the target (*Earth*) to display the VR object that represents earth. The second adaptation rule (Figure 7 (B)) is on a single learning concept (*Earth*). The rule uses a *touch* VR event and the *disable_interaction* adaptation type to disable user interaction with the *Earth* 3D object once the learner has already interacted with it too many times. In both examples, a notification message is provided.

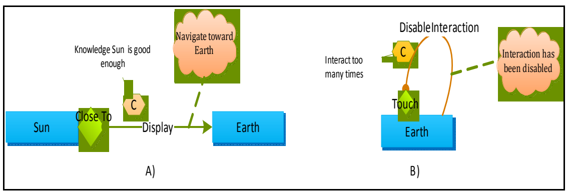

Figure 7: Examples of adaptation rules: A) adaptation rule between two learning concepts; Sun and Earth, B) adaptation rule on a single learning concept.

3 PILOT EVALUATION

The goal of the conducted evaluation was to perform a first evaluation of the modelling languages from a usability and acceptability point of view, in order to evaluate whether the approach taken was appropriate and to gather feedback to improve the languages before starting to implement tool support.

As we were looking for critical feedback from the viewpoint of usability and user satisfaction, we asked PhD students from our universities to participate in the evaluation. Four PhD candidates and researchers and ten instructors were involved in the evaluation. All of them were from the Computer Science department, but they were rather novice in 3D or VR.

The evaluation was divided in three steps. The first step introduced the participants to the different notations of the languages; example models created using the languages; a list of available Pedagogical Relationship Types and their default associated update rules; and a selection of possible adaptation types.

In the second step, the participants had to do an authoring task, i.e. designing an adaptive 3D VLE about the Solar System using the three languages. This authoring task was done using regular paper and pen. Because it was not our purpose to evaluate an authoring tool, but rather the level of expressiveness of the visual notations of the proposed languages and the effort needed to create an adaptive 3D VLE using the graphical languages, the use of pen and paper is acceptable. This approach also avoided that we already spent a lot of resources on the development of a software tool before receiving any feedback on the proposed languages. However, we also admit that using paper-pencil rather than an authoring tool also has some limitations. For instance, a software tool could guide the correct use of the languages; this cannot be achieved with pen and paper. To solve such issues, an instructor was responsible for guiding and helping the participants with syntactical issues.

In the third step, the participants filled in an online questionnaire. The questionnaire was carefully constructed to reduce possible bias. For instance, there were positively as well as negatively formulated questions, and questions were formulated carefully to avoid that participants might be encouraged to give more favourable answers (Lazar, Feng, and Hochheiser, 2010, p.196). Furthermore, the questions' order was in such a way that the answer to one question did not influence the response to another question. Furthermore, each participant did the evaluation individually, the results were treated anonymously, and the participants were informed that there were no right or wrong answers and that it is was not an evaluation of the participants themselves.

The questionnaire was composed of questions from six categories: Demographic Information, Authoring Adaptive 3D VLE (A3DVLE), ISONORM 9241/110-S Evaluation Questionnaire (ISONORM) (Prumper, 1999), Subjective Impression Questionnaire (SIQ) (Davis et al., 1989), Qualitative Feedback (QF), and Workload Perception (WP) (Hart and Staveland, 1988).

All questions were mandatory. As already indicated, there were positively formulated questions and negative formulated questions and all closed question had a Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree). For each individual evaluation feedback on a positive question, a score of 3 or higher was considered as "good", as well as a score of 3 or lower on a negative formulated question.

4 EVALUATION RESULTS

All participants were from the domain of Computer Science, but the demographic data indicated that only few participants were familiar with VR/3D (5 out of 14 participants). However, all participants were using the computer on a daily basis. The average age was 32 (youngest was 26, eldest 36). The majority of the participants were males (11 out of 14). Only 2 (out of 14)participants reported to be inexperienced with authoring standard courses. But most of the participants (11 out of 14) had only limited experience in authoring 3D VEs or videogames in the context of e-learning. All participants were familiar with graphical modelling languages like UML.

In average, participants spent about 40 minutes on the tasks (best time was 25 min.; worst was 90 min.).

Usability:
The usability of the graphical languages was evaluated as 'Medium/Neutral' to 'Good to Perfect'. The bars chart in Figure 8 presents the results concerning both ISONORM and A3DVLE questionnaires. 8 positive formulated questions related to the A3DVLE questionnaire that were evaluated as 'Good to Perfect', while 3 questions (positive formulated) were evaluated as 'Neutral'. Concerning the negatively formulated questions in the A3DVLE questionnaire, 4 questions were rated as 'Good to Perfect', 2 questions as 'Neutral', and 1 as 'Poor'. 5 questions related to ISONORM 9241/110-S questionnaire were rated as 'Good to Perfect' and 3 questions as 'Neutral'. We now provide more details.

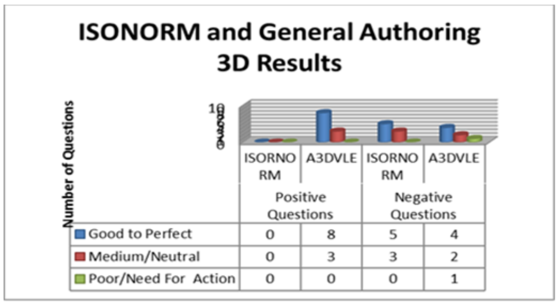

Figure 8: ISONORM and General Authoring 3D VLE Questionnaires Results.

In general, all questions related to the *suitability for the task, conformity with user expectations, self-descriptiveness, usefulness* and *easy-to-use*, were rated good. The visual notations of the modelling language allowed the participants to do the authoring task without being 3D/VR experts. The overall positive feedback on the usability questions indicates that the modelling languages are appropriate for the task. In addition, most of the participants considered the modelling languages rather intuitive. However, we have to note that the participants had a good knowledge of modelling.

However, also a number of questions received a neutral score. In particular, the questions related to the *suitability for learning* were rated as 'Medium/Neutral'. Furthermore, questions related to understanding the goal of pedagogical model were towards 'Medium/Neutral'. Although many participants agreed that there were no unnecessary input or effort, some of them spent quite some time in understanding the adaptation types provided and defining the course structure before they could start with the actual design of the adaptive 3D VLE. The question "*The defined Pedagogical Relationship Types are difficult to understand*" was rated 'Poor'.

Acceptability:
The different acceptability aspects scored in average good (see Figure 9). 4 questions related to perceived ease of use were rated as ‘Good’, while the other questions (3 questions) were rated as “Neutral’. Concerning the two questions related to attitude, 1 question was rated as ‘Good’ and the other was rated as ‘Neutral’. Finally, the perceived usefulness questions (2 questions) were rated as ‘Good’.

Given the fact that 11 participants (out of 14) had only limited experience in authoring 3D VLE’s or videogames, we rather expected a neutral rate to the *perceived ease of use* and *attitude.* But the scores were in average good. However, some participants gave a neutral rate to the aspect *perceived usefulness*.

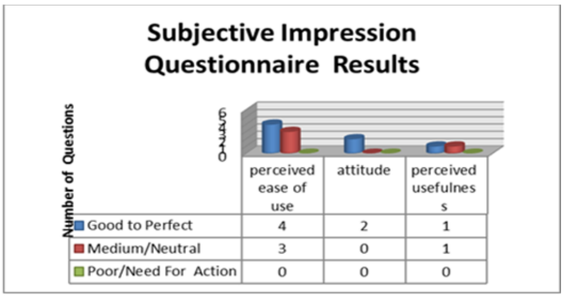

Figure 9: Subjective Impression Questionnaire Feedback.

Qualitative Feedback:
The open questions were about three aspects: *appreciation, depreciation,* and *recommendations*.

Appreciation
Most of the participants (11 out of 14) noted that they liked the fact that there are three modelling languages for creating the whole adaptive 3D VLE. Further on, ease of use and consistency was mentioned (7 times). Others (5) considered the availability of the predefined adaptation strategies, which could be applied to all 3D objects related to a topic, as very useful.

Concerning the question “*Was the Adaptive Storyline Language expressive enough to specify the overall storyline of the adaptive 3D course? (Please describe why*”), answers revealed that connecting topics with adaptation rules helped to define the overall flow of the storyline. In particular, 8 participants liked the adaptation rules between topics and the fact that they could choose which adaptation strategies to apply to the 3D objects inside the topic.

Concerning the question “*Was the Adaptive Topic Language expressive enough to specify the details of each topic? (Please describe why)*”, 4 participants highly appreciated that they could specify which adaptation types to applied to different 3D objects. Furthermore, being able to define when the adaptation type should be triggered by means of a VR event helped them to obtain a general overview of when the adaptations would take place. In addition, 7 participants gave a credit to the possibility of being able to give messages to the learner.

Depreciation
In responding to the question “*What did you like least about the authoring approach in general and its languages?*” answers revealed some limitations and flaws summarized into the following categories:

- A need for software tool (3 times)
- Using different adaptation types to the same object was confusing (4 times).
- The need to specify learning concepts for each topic was confusing (1 time).
- Distinction between the adaptive storyline and adaptive topic (6 times).

The answers on the question “*Was the Pedagogical Model language expressive enough to specify the pedagogical aspects for the adaptive 3D courses? (Please describe why)*” provided some explanation why the question “*The defined Pedagogical Relationship Types are difficult to understand*” received the score ‘Poor’. For instance, 6 participants needed quite some time to understand the meaning and the use of the Pedagogical Relationship Types (PRTs). Others (7) found the use of different colours for different PRTs confusing.

Recommendations
In responding to the question “*What should be improved and how?*” most of the answers were related to the need for a supporting tool. Indeed, the use of the modelling languages within an authoring tool could support the authors with different help mechanisms like tool tips and tutorials. Furthermore, it would be easier to detect errors in the models. Another issue related to a supporting tool is the fact that a tool could ease the specification/modification, e.g., by providing menu’s.

Workload Perception:
Participants were requested to give feedback on the mental demand, the effort required to accomplish the task, and their frustration. Most of the answers were neutral, but some frustrations were reported. For instance, some participants were wondering whether it is the author’s role to make sure that the order of learning concepts in the Storyline Model

should be consistent with the Pedagogical Model. This is indeed a fair question. However, providing an authoring tool that checks the consistency of both models can easily solve this. This is feasible as authoring tools in the context of adaptive hypermedia such as AHA! (De Bra, Smits and Stash, 2006) and GRAPPLE (Hendrix et al., 2008) already check adaptation rules.

5 DISCUSSION

Overall, the evaluation results of the graphical languages were quite positive. However, it is necessary to recall that all participants were computer scientists; this could have influenced the results. However, most of them did not have true experience with developing 3D/VR application, which corresponds with one of the main characteristics of our target users. Furthermore, conducting an empirical evaluation with a relative small number of users (14 participants in our case) may also affect the validity of the result of the evaluation. However, this evaluation was a pilot evaluation and performed in order to obtain a first feedback.

Usability and *acceptance* results were good despite the fact that most of the participants lacked experience in authoring adaptive 3D VLEs and there was no true learning period, while it is obvious that some time is required to get acquainted with the visual notations.

The *effectiveness* of our authoring approach turned out to be good in this evaluation since all participants were able to define the adaptive 3D VLE in the right way. They could specify an adaptive storyline and managed to specify adaptation for the topics. Furthermore, the decomposed specification of a topic adaptation rule, into a VR event to trigger the rule, a condition that needs to be satisfied, and the resulting action (the adaptation type), made it easy for the participants to keep an overview on the adaptations.

In addition, the qualitative feedback provided useful information for further work. As expected, tool support is essential. But also some specific requirements related to tool support were given, such as pull down menu’s to select the User Model and 3D VLE activity history attributes when (re)defining the update rules in the pedagogical model, as well as when defining the adaptation rules in the adaptive topic model. Interesting to note it that in the evaluation, the 3D VLE activity history attributes and the User Model attributes were given as one list, although conceptually there are separated in our approach. We thought one list would be simpler for the author, as both categories of attributes may be needed in the context of defining the adaptive topic model. However feedback indicated that it would be better to keep this conceptual difference and to present them as two separate lists. Furthermore, the use of different colours for different Pedagogical Relationship Types surprisingly turned out to be confusing and it was advised to remove this or leave it up to the author to define when different colours should be used.

6 CONCLUSIONS

We presented and discussed a usability evaluation of graphical modelling languages developed to support 3D-novice educators in the process of specifying (i.e. authoring) adaptive 3D VLEs.

The evaluation was done with 14 people from the domain of Computer Science. After an introduction to the approach, they performed an authoring task. Next, they filled in a questionnaire consisting of closed, as well as open questions. The results indicate that the modelling languages proposed are intuitive and can be used by people without deep knowledge of 3D/VR to perform the authoring process within a fair period of time. Moreover, the participants found the visual notations easy to use. Not surprisingly, the evaluation revealed the need for software support.

We acknowledge that the evaluation has some limitations, the most important ones being: the fact that the participants were computer scientists and the limited amount of participants. Also the fact that the authoring exercise was done with pen and paper can be a limitation. On the other hand, it avoided that the tool was evaluated rather than the languages. In order to fully evaluate our approach, additional evaluations should be conducted when a (functional prototype of an) authoring tool has been developed with a larger number of people including people with different backgrounds, like experts in VR for validating the advanced features as well as non-technical people, people with and without modelling experience, and people with different teaching experience. It may also be important to measure the required time for completing the tasks by the different categories of users. If the time required to author a course is too long, people may not be prepared to use it in practise.

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Automated Generation of High School Geometric Questions Involving Implicit Construction

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Keywords: Automated Deduction, Constructive Geometry, Graph-based Knowledge Representation.

Abstract: We describe a framework that combines a combinatorial approach and automated deduction to generate geometry problems which require implicit constructions for their solution. This is an extension of our framework developed for generating geometric questions without construction. Such a system would help teachers to quickly generate large numbers of questions involving implicit construction on a geometry topic. Students can explore, revise and master specific topics covered in classes and textbooks based on construction-based generated questions. This system may also help standardize tests such as GMAT and SAT. Our novel methodology uses (i) a combinatorial approach for generating geometric figures and objects for construction (ii) automated deduction to generate new questions and solutions. By combining these methods, we are able to generate questions involving finding or proving relationships between geometric objects based on a specification of the geometry objects, concepts, theorems and construction object to be covered by the questions. Experimental results show that a large number of questions can be generated in a short time.

1 INTRODUCTION

Construction-based Euclidean geometry questions refers to geometric questions which require constructions, namely, to find proofs with additional lines, points, or arcs constructed by a compass and a ruler. Finding a construction is a hard task even for human problem solvers. Since one can draw many segments and arcs at any point of a proof, the search space is enormous. Hence generating construction-based questions on a user-selected geometric topics is a more challenging task.

It is important to understand construction-based geometry when studying a course because it does not follow any set pattern. In Euclidean geometry, one can only learn the axioms and results proven from these axioms. The student must apply these axioms with no set pattern or list of steps for solving such questions. Therefore, a question may have (possibly infinitely) many solutions. To practice the required problem solving skills, students require a large number of different types of geometry questions on various concepts which requires implicit construction of various geometric objects. Generally, textbooks and online sites provide a limited predefined number of such type of questions for each topic. Once practiced, these questions lose their purpose of enhancing student thinking. The tedious and error-prone task of generating high-quality questions challenges the resources of teachers. Hence, there is a need for software which assists both teachers and students to generate geometry questions and solutions.

Apart from helping users, the framework of generating questions has scientific contributions to other research areas, such as Intelligent tutor systems (ITS) and Massive Online Open Courses (MOOC).

Various research has been performed in automated deduction of theorems at high school level in the geometry domain, although none with the goal of automatic construction-based question generation. Instead, they mainly demand users to generate the question with the help of tools. In addition, they mainly focus on solving and assessment of the questions. Our survey shows that the currently available geometry systems, such as JGEX, Geogebra, Cinderella and Sketchpad, are not able to automatically generate questions of user specified geometry topics. The closest software is GRAMY tool which can solve questions involving implicit constructions. However it is unable to generate such questions.

The aim of this paper is to develop a framework that can be used to generate construction-based geometry questions based on specific inputs, such as geometry objects, theorems and construction objects to be involved in their solution. For a given set of geometry objects, the algorithm can generate a large set of questions along with their solutions. The solutions will involve user desired theorems directly or indirectly. Hence the framework can generate questions to test the theorem on various geometry objects and concepts.

Generated questions from our framework having implicit construction may involve algebraic computations for a solution. Currently, we restrict the relationships between quantitative entities to linear ones. Our framework has a predefined database of theorems, concepts and construction objects which can be used for generating questions. Given a set of user-selected construction objects, our system can generate all possible questions using an existing database of concepts and theorems.

The main contributions of this paper are as follows:

1. Our geometry question generator combines the complementary strengths of a combinatorial approach, pattern matching and deductive reasoning. Construction-based geometry questions can be generated which were not possible previously.
2. A substantial evaluation is provided that demonstrates the effectiveness of our generator. The question generator was able to generate most of the questions, involving implicit construction, covered in the textbooks based on targeted queries.

2 RELATED WORK

There are several automated theorem proving system in the geometric domain such as JGEX (Gao and Lin, 2004), Cinderella and Geometry Explorer (Wilson and Fleuriot, 2006) that allows users to build proofs based on geometric constructions. Angle method (Gao and Lin, 2004), Wu's method and Grobner basis method (Chou et al., 1994) are some of the methods used by the existing geometry systems for automatically proving geometric theorems. However, these methods are either not suitable for question generation or the approach used is not suitable for the high school geometric domain. Hence, the geometric systems are unable to automatically generate geometric questions.

GRAMY (Matsuda and Vanlehn, 2004) is a geometric system that can solve geometric questions which require implicit construction. It uses a forward chaining search followed by a backward step to suggest a construction. GRAMY can only discover proofs that do not involve arithmetic operations. For example, it cannot find proofs that involve inequalities and ratios.

An algorithm developed by Rohit (R. Singh and Rajamani, 2012) used a numerical approach for solving geometric questions involving construction. The algorithm uses the concept of randomness instead of performing symbolic reasoning. Hence, the solutions generated by this algorithm are based on numerical reasoning and out of the scope of high school mathematics.

Our original framework can generate geometric questions based on concepts, theorems and user-selected geometric objects. However, it cannot generate construction based questions. Current work is an extension of the framework developed in (annonymous, 2013).

3 GEOMETRY QUESTION GENERATION TASK

Mathematically a geometry question Q generated by our system can be represented by a sextuple (Object O, Concept C, Theorem T, Construction objects CObj, Relationship R, Query type Qt) where:

- O $\in$ (lines, triangles, square, circle, ...)
- C $\in$ (perpendicular, parallel, midpoint, angle-bisector, circumcircle...)
- T $\in$ (Pythagorean theorem, similarity theorem, various triangle-theorems, ...)
- CObj $\in$ (perpendicular, parallel, midpoint, angle-bisector...)
- R $\in$ (syntactic, quantitative)
- Qt $\in$ (syntactic, quantitative)

In order to generate geometry questions, the user has to provide a set of geometry objects O such as triangles, squares, etc., a set of concepts C and a set of construction objects CObj such as perpendicular, parallel, midpoint, etc., which the user would like to cover in the generated question. Optionally the user may select a set of theorems T to be tested by the question. The relationship R can be either syntactic such as perpendicular, parallel, etc., or quantitative such as the giving the length of an object, the ratio of two quantities etc. The query type Qt is the type of generated question that can be asked to find the hidden relationship which can be calculated from the given information. The solution of the generated question would require construction of user-selected

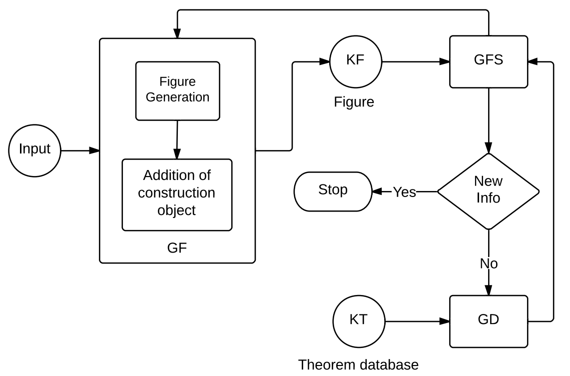

Figure 1: Connection of framework components and knowledge representations.

CObj. Next section describes the framework for generating such questions.

4 QUESTION GENERATION FRAMEWORK

Our framework comprises three major components along with the knowledge databases used for storing geometry figures and a set of predefined theorems. Figure 1 shows the connection of these components. The input consists of geometric objects, concepts, theorems and construction objects selected by the user. The input is fed into the first component, *Generating Figure (GF)*. This component is used for generation of geometric figures from the input. Each figure constitutes a diagrammatic schema (DS) (Greeno et al., 1979) and a set of unknown variables representing the relationship between geometric objects. User-selected construction objects are added to the figure generated by GF according to the algorithm described in the section 4.3. The geometric figure is passed to the second component, *Generating Facts and Solutions (GFS)*. This component is used to find values for the unknown variables representing possible relationships to be covered by the generated question. GFS makes use of the predefined knowledge database of axioms. It results in the formation of a *configuration* (Cfg) containing known values for some relationships between its objects. New information is derived from the configuration Cfg. New information refers to the generation of suitable questions. A question is considered suitable if it covers the essential information such as a new fact and a proper reasoning for the generated fact. A new fact would not be related to the construction object CObj. However, the reasoning of the fact generation would involve the use of CObj.

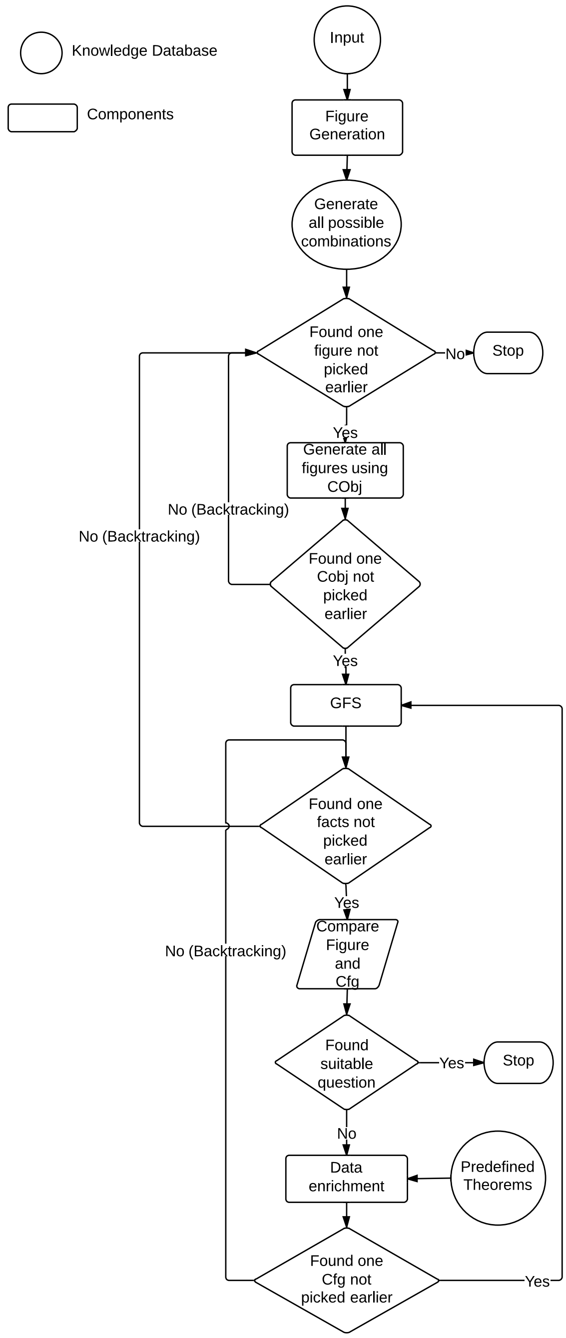

Figure 2: Flow diagram of the algorithm for generating questions.

If the suitability conditions for the generated configuration (Cfg) are not met then the configuration is fed into the last component, *Generating data for the figure (GD)*. GD assigns values to unknown variables of relationships. Repeated processing by GD makes the questions generated from Cfg easier and easier, because the values assigned by GD appear as given facts in the generated questions. GD makes use of a predefined set of theorems and makes sure that the assignment results in successful generation of geometry questions. The configuration generated from this component is again passed to the GFS component and this loop continues until a question is found which meets suitability conditions.

4.1 Algorithm

Figure 2 represents the flowchart describing the algorithm for generating geometric questions involving implicit construction. Algorithm 1 describes the flowchart in further detail.

In this section, Algorithm 1 is explained with the help of a running example. Figure 3 shows the step by step execution of the algorithm. We select the following input in our example.

- Object: triangle and line segment
- Concept: perpendicular
- Construction object: Parallel lines
- Theorem: Pythagorean Theorem
- Number of questions: 1

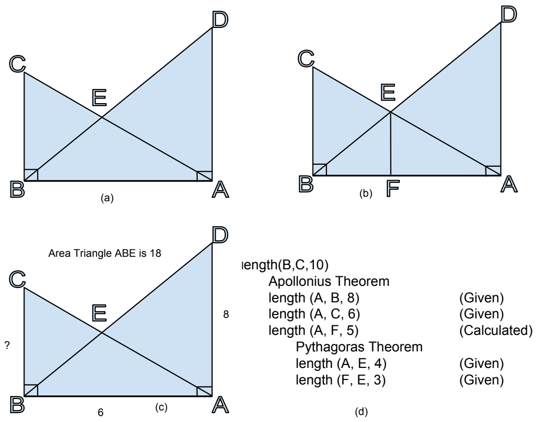

Figure 3: (a) The figure generated by using *triangle* and *perpendicular* as the geometry objects using the GF function. (b) A parallel line is drawn parallel to ”CB” from E meeting ”AB” at ”F”. (c) The data is generated for (b) using the GD component. (d) The new fact not involving EF and its derivation involving EF using the GFS component generated from the figure shown in (c).

In the next subsections, we will describe each framework component and its interaction with the knowledge databases.

Data: User selects object(s), concept(s), construction-object(s), theorem(s) and the number of questions to be generated.
Result: Question with single or multiple solutions.

1. Generate all possible figures consisting of geometry objects using GF function from the given input.
2. Find one figure which has not been picked earlier. If found, go to next step else terminate.
3. Add Cobj using the algorithm mentioned in the section 4.3.
4. If new figure is generated, go to next step else do backtracking.
5. Save this figure using KF knowledge database.
6. Assign values to variables of figure obtained in second step from the predefined knowledge database of axioms through GFS function. Configurations (Cfg) are generated from this step.
7. Find one Cfg not picked earlier. If found, goto next step. If not found, backtracking to step 2.
8. Compare Cfg with the previously stored figure.
9. If the comparison gives the desired suitability then the Cfg is declared as a generated question and the algorithm stops. If the conditions are not met or more number of questions are required, go to the next step.
10. Configuration Cfg obtained from GFS is fed into the third component, GD, to assign more unknown variables. It makes use of KT, a predefined database of theorems.
11. From the configurations obtained from GD, find a new configuration Cfg which has not been chosen earlier. If found, goto step 3. If all configurations have been chosen earlier, goto step 5.

Algorithm 1: Algorithm for generating geometry questions.

4.2 Generating Figure Configuration from the User Input (GF)

This is the first step executed by Algorithm 1 described in Section 4.1. This component is further divided into two sub-components, *Figure Generation and Addition of construction object*. First sub-component generates a figure through the combination of a predefined number of ways to combine geometric objects. Currently, we are focusing on triangles and line segments. Hence our algorithm includes combinations in which various triangles and lines can intersect. Furthermore, we are currently limiting our algorithm to the intersection of two triangles. Adding more objects may make the figure more complex, possibly leading to unusual questions that are not commonly found in textbooks. However there is no limitation on the intersection of lines and triangles.

Adding Construction Object from the Figure Generated by GF

This component is used for adding geometric objects which will not be shown in the generated question. However, the construction of the object would be required by the user to prove/solve the questions. Generally, more than one construction object can be added for generating questions. However, we have limited our algorithm to addition of single object. Addition of two or more objects may lead to the generation of questions very hard to solve and may not solve the purpose of testing the concepts.

Figure 4 describes the algorithm for adding a construction object in a figure (input) generated by the first sub-component. The algorithm first checks for the user-selected construction objects. If the user has selected an object, the algorithm looks for the preexistence of the selected construction object. In case the object is not present, algorithm adds it in the figure and terminates. The algorithm does nothing if the user-selected object is already present in the figure.

Currently, our algorithm is limited to the construction of a line between two existing points, parallel, perpendicular line and median in a given figure.

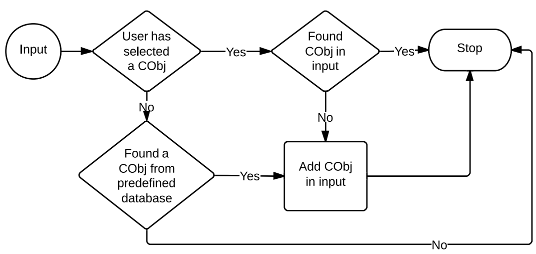

Figure 4: Explains the algorithm for adding construction objects in a given figure.

4.3 Generating Facts and Solutions (GFS)

This component is responsible for finding the values of unknown variables of the generated configuration from the other components. This component acts as question generator and solver. The unknown variables whose values have been found represent the generated questions. The steps that leads to finding the unknown variables represent the solution. The algorithm will consider only those facts which do not include CObj but make use of CObj for reasoning. Figure 3d shows an example of such a fact. The new fact is related to the length of side CB of a triangle. However, it requires the construction of a perpendicular line from E to AB.

There may be several ways for finding the values of the unknown variables. In such cases, this component shows all solutions. For generating the new facts, it uses a predefined database of theorems. The theorems are represented in the form of axioms. We have used The School Mathematics Study Group (SMSG) axiomatic system, which is a combination of Birkhoffs and Hilberts axiom (Francis,2002) systems. More details can be found in an algorithm (annonymous, 2013).

4.4 Generating New Configurations (GD)

This component starts with a search for user-selected theorems. If the user has not chosen any theorem, a theorem is non-deterministically selected from the predefined knowledge database of theorems. Our algorithm terminates when all theorems have been selected once for a given figure configuration. After theorem selection, pattern matching on the theorem figure is performed. If a matching pattern is found, a set of input and/or output values are assigned to the chosen pattern. This assignment is done with the help of a predefined set of theorems. In case no pattern is found, a new theorem is chosen from predefined theorem database, KT, and the whole process is repeated until we get the desired configuration. More details can be found here (annonymous, 2013).

5 IMPLEMENTATION

Each component of our tool is implemented independently, using state-of-the-art libraries and systems.

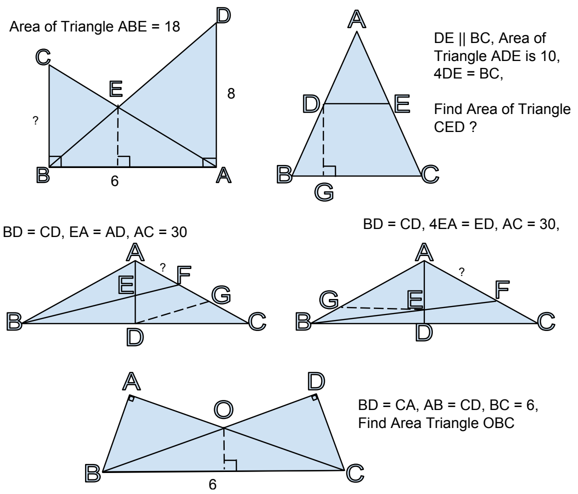

Figure 5: Figure (a) can be solved by drawing a perpendicular from E to AB (b) A perpendicular is drawn from D to CB (c) A parallel line is drawn from D to AC (d) A parallel line is drawn from E to BD (e) Three lines are drawn joining existing points, AR, BP, CQ.

C++ is used for performing calculations and Python is used for implementation of the algorithm and predefined knowledge databases. Constraint Handling Rules (CHR) (Frühwirth and Raiser, 2011) are used for generating new facts from the axioms and the given facts. For implementing knowledge representation, the graph database Neo4j (Vicknair and Macias, 2010) is used. Both questions and a set of predefined theorems are represented using Neo4j.

Results

Our system can generate geometry questions using the framework described in Section 4. Currently, our knowledge database of objects contains line segments and triangles. In addition, we have a predefined set of more than 100 theorems. The generated questions cover four construction objects, e.g. perpendicular line. Figure 5 shows various questions generated by our system on selecting "*triangle*" as object and various CObj such as parallel line, perpendicular line and median. The dashed lines in the Figure 5 represent construction of the CObj required to solve the question.

GRAMY (Matsuda and Vanlehn, 2004) is a geometric system that can solve geometric questions which require implicit construction. However, due to inavailability of GRAMY's source code, we cannot validate the questions generated by our framework.

6 CONCLUSION

In this paper, we provide a framework for the automatic generation and solving of geometric questions which require implicit construction of geometric objects for their solution. Our system is able to quickly generate large numbers of questions on specific topics based on construction objects. Such a system will help teachers reduce the time and effort spent on the tedious and error-prone task of generating construction-based questions.

Future work involves conducting experiments in which the teachers would be asked to differentiate between the textbook questions and the framework generated questions. Another major improvement would be to generate questions according to the required difficulty level in addition to the implicit construction of objects.

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A Framework for Curriculum Management
The Use of Outcome-based Approach in Practice

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Keywords: Curriculum Planning, Outcome-based Approach, Web-oriented Platform, Technology Mashups.

Abstract: The need for guaranteed and high-quality education involving predefined curricula covering a corresponding scope of input knowledge and skills required in subsequent practice has been gaining momentum. Universities compile their curricula so as to ensure that they cover all steps essential for the students to obtain employment later on. In the paper a brand new and original curriculum harmonization approach within tertiary education is described by adopting an outcome-based approach and applying modern information and communication technologies. We propose a model for curriculum management and show how the model was implemented into practice in a particular field of study by using complex web-oriented platform. Its primary objective is to make all efforts expended by users more efficient, as regards to the creation, editing and control mechanisms in the form of deep content inspection.

1 INTRODUCTION

The proliferation of web technologies, in conjunction with the social demand for improved access to tertiary education, have stimulated the rapid growth of e-learning (Chiu and Wang, 2008). Individualised ease of access to information resources and time flexibility or independency are the major advantages impacting the users. Today, modern information and communication technologies (ICT) offer an interesting opportunity to revolutionize the way education is provided (Barnes and Friedman, 2003). The list, annotations and curricula of compulsory subjects, compulsory-optional courses and optional seminars are available to students and teachers – typically in the local learning management systems. However, the differing levels of detail and description style lacking any kind of standardization or parameterization hamper transparency and comprehensibility, particularly when searching for information on the entire course of studies. As a result, it is very difficult to look at the whole field, specialization or studies from a broader perspective and to enjoy the possibility of searching easily across the curriculum and finding one's way through it to see what is actually being taught and how.

For many years, academic staff (such as teachers and guarantors) has been in close touch with sophisticated online educational tools. Hundreds, if not thousands, of web-based tools have been created in the last few years, taking the technology as a tool metaphor to a new level (Oliver, 2010). These systems have facilitated institutional curriculum planning activities related to the creation of well-balanced education. For an instance, the CanMEDS initiative of The Royal College of Physicians and Surgeons of Canada has introduced the implementation of a national, needs-based, outcome-oriented, competency framework that sets out the knowledge, skills and abilities for specialist physicians in order to achieve better patient outcomes (Frank and Danoff, 2007), (Frank and Bernard Langer OC, 2003). In (Huang, 2001), the author presented an integrated outcome assessment application that was completed by a database designed to accumulate learner performance outputs and to store them as a prat of learner's profile. Data from the profiles can then serve as valuable inputs in providing personalized and customized learning content or to conduct an overall performance evaluation. Y. Mong et al. (Mong et al., 2008) have described the web-based application LOTS (Learning Outcome Tracking System), which provides overall management of the learning outcomes and access for both the student and the teachers. In brief, LOTS consists of six components, namely group, metric, learning outcome, incident, correlation and analysis. The generic electronic portfolio called ePortfolio (Cotterill, 2004) has introduced an approach, which is being used to support the evidencing of learning outcomes and to facilitate personal development planning. In modular courses, portfolios may provide focus on programme-level as well as module-specific learning outcomes. The whole process may help students to become better at relating what they learned to the requirements of teachers. S. Kabicher et al. have presented a sophisticated approach, the use of visual modelling within an interactive online environment (ActiveCC Web) for a collaborative design, the implementation and visualization of the curriculum structure and the content (Kabicher and Derntl, 2008), (Kabicher et al., 2009). One of the options for describing the content related to the curriculum is a special taxonomy. T. G. Willett et al. have introduced TIME (Topics for Indexing Medical Education), a hierarchical taxonomy of topics relevant to medical education. The content and the structure of the topics within TIME was developed in consultation with medical educators and librarians at several Canadian medical schools (Willett et al., 2007). Existing solutions, that were published, are focused on the curriculum only from a certain perspective, offering the agenda together with selected functionalities and making the efforts to provide them to students and teachers of the respective institution in a transparent format. However, we have not yet seen a complex instrument that would cover all elements associated with global curriculum harmonization, including a detailed parametric description down to the level of the learning units, and one that would be linked to the learning outcomes (Komenda et al., 2013).

2 OBJECTIVES

Many thoughtful attempts were made in order to develop a curriculum mapping or model, which should increase academic rigor, sharpen students' critical thinking and analytical reasoning, and expose them to a richer subject matter. Consequently, three following main research strides emerged. 1) Instructional methods cover many innovative methods in higher education: active learning, experiential learning, inquiry-based learning, discovery-based learning, problem-based learning, project-based learning, collaborative and cooperative learning, and understanding by design. 2) Evaluation and assessment provide new methods developed to promote Bloom's higher-order thinking and other competencies required in the employment market such as self-assessments, students' portfolio, open book test, case studies analysis, group projects, prototyping, and technology-based evaluation. 3) Curriculum coherence and integration focus on reforms in the curriculum structure: the integration of general education across the curriculum, the integration of the disparate elements of students' learning experiences, and shifting from curriculum objectives to attaining competencies (Pasha and Shaheen Pasha, 2012). With regard to the mentioned areas, this paper introduces an innovative curriculum planning model, which is based on the outcome-oriented paradigm. This performance-based approach at the cutting edge of the curriculum development offers a powerful and an appealing way of introducing effective reforms in education management. Here, emphasis is on the product – what sort of graduates shall be produced – rather than on the educational process itself (Harden, 1999). Our research is concentrated on the following topics.

- To propose a curriculum planning model, which would channel clear communication between the involved stakeholders (supervisors, guarantors, managers and teachers).
- To develop a robust web-oriented platform for complex curriculum management, which would provide a set of effective tools to be used for creating, transparent browsing, and reviewing the curriculum in a user-friendly environment.

A pilot curriculum reform and harmonization using the described approach has been already done within the study discipline of Mathematical Biology, which is part of the Experimental Biology curriculum at the Faculty of Science of Masaryk University in Brno, Czech Republic. The goal of this field of study is to produce professionals in the domain of data analytics in clinical, biological and environmental research. It also enables to attract a new generation of interdisciplinary experts, needed for processing and analysing data from experiments as well as for properly interpreting the obtained results, including communication and collaboration with other experts in the given fields.

What will such an approach to curriculum planning and harmonization bring for the student? It will provide clear information about what knowledge shall be acquired during the whole study period, what topics will be in the schedule, what fields will be covered repeatedly and how the subjects will be interconnected with the learning units and the learning outcomes. As for the teachers, the description of the curriculum will mean an easy way of clearly defining their lessons. In addition, they will be able to browse the curriculum data from all available courses according to the predefined search parameters. And for the school managers, the presented tools will provide a practical view on the teaching. Further, it will also provide clear and comprehensible data about who teaches what and in what context, as well as information on the deficiencies and overlaps in the curriculum. One of the key benefits is a new kind of view on the correlations between the theoretical and practical parts of the study, which will help in deciding whether the overall teaching pattern is correct or some kind of restructuring is necessary.

3 METHODS

The current literature shows that the existing curriculum models are unable to represent the needs of the today's dynamic & complex education. This is due to the fact that the current society is more open, diverse, multidimensional, fluid and more problematical (Pasha and Shaheen Pasha, 2012). It is one of the reasons why the issue of innovation has been confronted in many fields as a mere tertiary field by different academic institutions, as the analysis of the current global situation indicates. However, today a coherent solution that would cover user-friendly tools for easy curriculum description is still missing. Therefore, we have proposed a methodological model, which is built on an outcome-based paradigm. The Bergen ministerial conference of the Bologna Process in May 2005 discussed reforms to degree structures, credit transfer, quality assurance and curricular development, which are transforming the European Higher Education Area. Learning outcomes are arguably best viewed as a fundamental building block of the Bologna education reforms and bring more transparency to higher education systems. They have a reputation of being rather mundane and prosaic tools, yet it is this basic underpinning function that makes them so significant. It is important that there should be no confusion about their role, nature and significance, or the educational foundations of the Bologna process will be undermined (Keeling, 2006). The use of the mentioned concept implies a fundamental paradigm shift in curriculum design for many European institutions offering higher education (Adam, 2004).

We also present here an original instrument based on approved pedagogical methodology with the integration of ICT mashups into the curriculum management process. This web-based tool called Learning outcome browser, which is part of our web/oriented platform, covers all elements pertaining to global curriculum harmonization, including detailed metadata specification down to the level of learning units and interconnections to the learning outcomes. It opens the possibility of reforming the curriculum structure effectively, as all elements are available in the form of parametric description. The organization of the data and its linking are provided in the curriculum model, which can be implemented without any restrictions within any database technology. Figure 1 shows a simplified entity relation data (ERD) model of the fundamental attributes in the proposed solution.

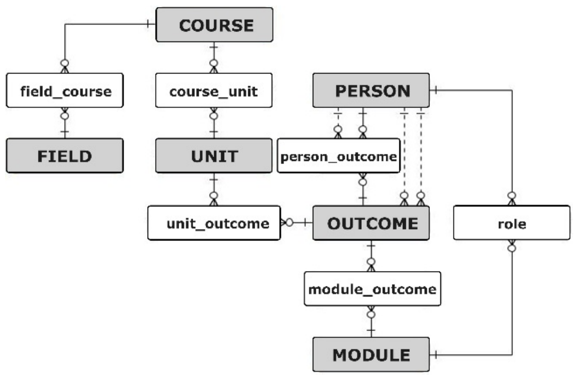

Figure 1: Simplified data model of curriculum.

There are a number of technologies used during the development process, rendering easy implementation afterwards. The web-oriented architecture runs on the most-used and widespread web servers – either an Apache server or a Microsoft Internet Information Server (IIS). We use Linux/Ubuntu and Windows Server operating systems for well-proven performance. All the tools were developed with the use of PHP (version 5.3.10), XHTML, CSS 2, JavaScript, AJAX and MySQL (version 5.5.32). We have also acquired the services of third party frameworks, such as jQuery (JavaScript library used for easier development of web-centric technologies), CKEditor (WYSIWYG text and HTML editor designed to simplify website content creation) and DHTMLX components (JavaScript grid control provides cutting-edge functionality, powerful data binding, and fast performance with large data sets).

4 RESULTS

We have proposed a model for curriculum management and harmonization and showed how the model was implemented into education in a particular field of study by using our original web-oriented platform. Its primary objective is to make all efforts expended by users more efficient, as regards to the creation, editing and control mechanisms in the form of deep content inspection. The platform enables to introduce reforms into the curriculum in several phases. Thus, unintended consequences or suboptimal solutions may be avoided.

The first phase sets up the structure of curriculum, which is described in figure 2. The study field is split into individual modules including details of the responsible supervisors. Each module contains a set of courses including its guarantors. The rules used for learning outcome definition have been already established according to the Bloom's taxonomy (Krathwohl, 2002). The composition of the study field is closely connected with the ERD model (see figure 1), which was designed to make whole curriculum domain more understandable. All the relations between modules, learning units, outcomes and involved stakeholders provide the basis for building web-based tool, which can easy organize the metadata about the education.

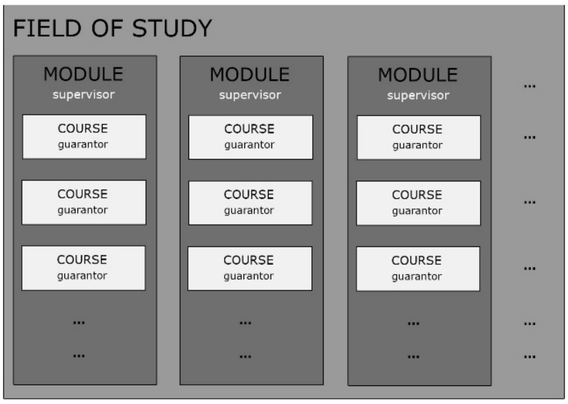

Figure 2: Proposed curriculum structure.

The second phase covers the definition of the learning outcomes (requirements on the graduate from the selected field) based on a predefined structure in an online environment including formal and semantic verification. Outcomes typically consist of a noun or noun phrase (the subject matter content) and a verb or verb phrase (the cognitive processes). Consider, for example, the following objective: The student shall be able to remember the law of supply and demand in economics. "The student shall be able to" (or "The learner will," or another similar phrase) is common to all objectives since an objective defines what students are expected to learn. Statements of objectives often omit "The student shall be able to" phrase, specifying just the unique part (e.g. "Remember the economics law of supply and demand."). In this form it is clear that the noun phrase is "law of supply and demand" and the verb is "remember" (Krathwohl, 2002). In our case each learning outcome is represented by the so-called data sentence, which is composed of a constant noun prefix, Bloom's taxonomy action verb and sentence (e.g. student shall be able to describe the principle of linear regression).

The third phase provides vertical harmonization, which consists of verification and further discussion within the individual module under supervision of the responsible guarantor. The fourth phase brings the process of horizontal harmonization, which consists of follow-up discussions across all modules under the management of supervisors. The fifth phase entails the creation of educational content according to the defined learning outcomes.

The authoring team, consisting of guarantors and teachers of Mathematical Biology study field, proposed a set of fundamental knowledge and skills known as GMER (Global Minimum Essential Requirements). This type of outcomes defines what students are expected to know, understand and/or be able to demonstrate at the end of a period of learning, typically as a graduate. This concept has been already used by a number of academic institutions, especially in medical education (Schwarz and Wojtczak, 2002), (Zhang et al., 2002). The idea of learning outcomes helps determine what teachers are supposed to teach, what students are expected to learn and what knowledge all alumni must have. It provides a correctly compiled and balanced curriculum across selected study fields. The management of Mathematical Biology is currently delegated to 21 teachers who interact with the study harmonization and streamlining process in different roles and provide feedback to the developers of the ICT mashups from which the web-oriented platform is composed.

Table 1: Summary of Mathematical Biology study field.

Total number of modules	5
Total number of courses	26
Total number of learning units	261
Total number of learning outcomes	1281
Total number of teachers and guarantors	21

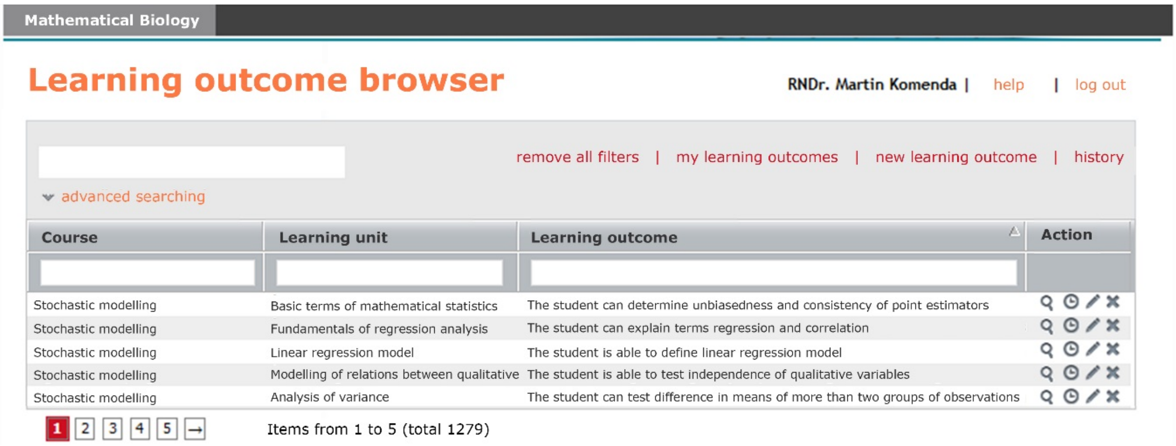

Figure 3: Overview of learning outcomes with the use of data grid component.

One part of the platform, which was developed and tested, is called Learning outcome browser and it is based on the data grid component (see Figure 3). It allows the users to access the data in a well-arranged form and offers the possibility of applying advanced search and filtering based on selected search parameters. Thus, it provides an easy, clear and user-friendly way of managing the curriculum, including evidencing all executed operations such as creating, editing and deleting learning outcomes and units. The browser, which enables various views on the curriculum for both teachers and guarantors, is available online after the login process at http://opti.matematickabiologie.cz/.

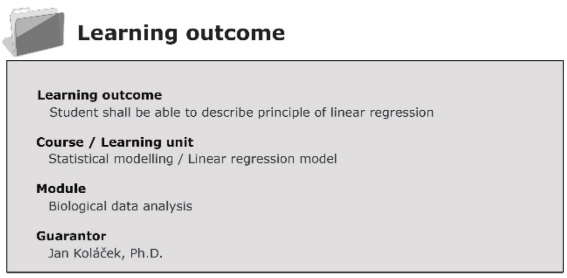

Figure 4: A learning outcome in detail.

The educational materials have been creating according to the presented methodological model and developed platform. It means that the content completely respect the structure of described courses and learning units and every individual topic is always introduced by set of learning outcomes. For the future works, we would like to analyse educational metadata which have been already defined by parametric elements comprising predefined attributes. For instance, selected natural language processing methods and visualisation techniques would be used for the classification of learning units into the classes or clusters, which can discover information rich relations, imperfections and potential overlaps across the chosen field of study. Moreover, we would like to assess the created curriculum from the Bloom's taxonomy perspective and divide all the learning units into cognitive, affective, and psychomotor domain.

5 CONCLUSIONS

In this paper a brand new approach to curriculum planning and management within tertiary education was described. It adopted an outcome-based approach and involved modern ICT technologies in mashups that composed an original web-oriented platform to implement the presented model approach into education. The presented methodology and the platform will help academics in their curriculum reengineering efforts, as it provides a transparent overview of the curriculum structure. Our approach as well as the platform was adopted in practice by senior teachers and professional guarantors within the content inspection of Mathematical Biology field of study. We believe that our model approach is robust enough to be applied with a small set of minor adjustments to any field of study. Further, we also showed how the entire harmonization process is phased to allow avoiding any suboptimal solutions. Unlike the developed web-oriented platform, the implementation of our model approach is fully independent in the particular ICT as well as on the particular field of study to be harmonized.

ACKNOWLEDGEMENTS

The authors were supported from the grant project Interdisciplinary development of the study Mathematical Biology reg. no: CZ.1.07/2.2.00/28.0043, which is funded by the European Social Fund and the state budget of the Czech Republic.

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Leveraging Video Annotations in Video-based e-Learning

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Keywords: e-Learning, MOOCs, Video Annotation, Pedagogical Processes.

Abstract: The e-learning community has been producing and using video content for a long time, and in the last years, the advent of MOOCs greatly relied on video recordings of teacher courses. Video annotations are information pieces that can be anchored in the temporality of the video so as to sustain various processes ranging from active reading to rich media editing. In this position paper we study how video annotations can be used in an e-learning context - especially MOOCs - from the triple point of view of pedagogical processes, current technical platforms functionalities, and current challenges. Our analysis is that there is still plenty of room for leveraging video annotations in MOOCs beyond simple active reading, namely live annotation, performance annotation and annotation for assignment; and that new developments are needed to accompany this evolution.

1 INTRODUCTION

While video material had been used for several decades as a learning support, the development of web-based e-learning first caused a setback in the usage of pedagogical videos, due to lack of network bandwidth or standardized formats and software. However, video streaming, video hosting and the dissemination of capture and editing tools have come along and supported the exponential growth of video usage on the Web. Again video became an important component of e-learning setups, through the OpenCourseWare movement and the recent advent of Massive Online Open Courses (MOOCs).

Video annotations (section 2) are information pieces that can be anchored in the temporality of the video so as to sustain various processes ranging from active reading to rich media editing (section 3). Our main interest in this position paper is related to how video annotations are and can be used in e-learning context - especially MOOCs - from the triple point of view of pedagogical processes (section 4), current technical platforms functionalities (section 5), and current challenges (section 6). One of the most important results of our analysis[1] is that there is still plenty of room for leveraging video annotations in MOOCs beyond simple active reading, namely live annotation, performance annotation and annotation for assignment; and that technological improvements are needed to accompany this evolution.

[1]This work has received a French government support granted to the COMIN Labs excellence laboratory and managed by the National Research Agency in the "Investing for the Futures" program ANR-JO-LABX-07-0J.

2 VIDEO ANNOTATIONS

Active reading is a process where a reader assimilates and re-uses the object of his reading, as part of his knowledge work (Waller, 2003). The goals may be the exploration of a document, its enrichment or its analysis, for oneself or within a collaborative activity. Active reading usually relies on annotations, that add some information to a specific section or fragment of the target document, and can thereafter be reused along it for searching, navigating, repurposing, etc.

The link between the annotation and the original document may be more or less explicit, from the handwritten note in the margin of a book to the note taken on a notebook while watching a movie (which will involve more work from the annotator to specify the targeted information). Two main components of an annotation are usually considered: its content and its anchor. The content may take any form, as long as the underlying support allows it, and can be more or less structured. Anchoring will depend on the nature of the annotated document, and will be more or less explicit and easy to navigate.

We specifically position ourselves in this article in the audiovisual context. Video documents present a number of specific or more stringent issues. First, contrary to text content, they do not have any implicit semantics: any active reading must thus be mediated through annotations that provide an explicit information layer along the document. Second, contrary to text reading, the reading speed is imposed by the player. The annotation process then requires some kind of interruption or interference from the viewing process, and this conflict between the temporality of the video and that of the annotation process must be addressed somehow.

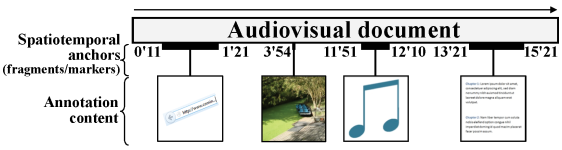

Figure 1: Video annotations anchors and content.

A video annotation is composed of data explicitly associated to a spatiotemporal fragment of a video. As illustrated in Figure 1, the spatiotemporal anchors define at least a timestamp (in the case of durationless fragments, specifying a single time in the document, e.g. 354), but more generally a begin and an end timecodes (e.g. 1321 and 1521). They may additionally address a specific static or dynamic zone of the displayed video (e.g. a rectangle shape that would follow a player in football video).

Video annotation content data can be of any type. Textual data is most often used, since it is the easiest to produce and to consume, but any content (audio, images, video, key/values...) can as well be associated. For instance, in a language learning context, the tutor can take textual notes about a video recording of a session, and also annotate by recording some spoken words to indicate the correct pronunciation. Annotations can also be articulated through some structure, such as a type classification: a feature movie analysis could for instance define different annotation types like Shot, Sequence or Character appearance (see figure 1).

3 USING VIDEO ANNOTATIONS

Annotations can be created manually or automatically. Manual creation involves various user interfaces, depending on the nature of the task and on the information that has to be captured (see VideoAnt and Advene in figure 2). Annotations may also automatically be created by extracting features from an actual video document (through speech recognition, or automatic shot detection for example) (Nixon et al., 2013), or by capturing synchronized information during the very recording of the document. This last case is used for instance when recording information about the activity of a user: an ergonomics researcher studying the use of a software can capture a recording of the user screen while using the software, along with more discrete information capture from the software (button clicks, file openings, etc.).

Beyond information retrieval and search, which is routinely carried out in active reading activities or in video monitoring systems, video annotations can be used in a variety of ways, such as enrichment and document creation.

Enrichment of the rendering of the video document is not new: subtitles can indeed be considered as video annotations, that are displayed as a caption over the video. But such overlays can also be graphical, to attract the attention of the viewer on a specific visual element. Video enrichments produced from the annotations can also be placed along the (original) video player, to produce a navigable table of contents for instance. Video annotations can also be used to create other documents, be it other videos as it is the case in video summarization (automatic or guided); or more rich-media documents as an article illustrated with some fragments (through the annotations) of the video; or even an annotation-based hypervideo that permits the navigation from one video to the other. Eventually, collaborative activities can greatly benefit from annotations, that here serve as an interpretative layer between participants.

These different types of uses can be put to use in different application domains. **Video archives** (e.g. TV, surveillance) can propose an enhanced access to their collections through video annotations, allowing to find specific video fragments. The Yovisto platform[2] (Waitelonis and Sack, 2012) offers for example access to video through semantic annotations, allowing to look for specific location, people, events... **Sports analysis** also greatly relies on video material, which can be used in a reflective way by offering the sportsman to view his own performance, or to analyse the behaviour of adversaries on recordings of previous competitions. Many applications such as EliteSportsAnalysis or MotionView Video Analysis Software offer tools to annotate and analyse sport performances. **Research on activity** in domains such as ergonomics, animal behaviour, linguistics, etc. also uses annotation software, since researchers need to perform a precise analysis of video recordings. There exist a number of research tools such as Advene, Anvil or Transana, as well as commercial offers like Noldus. They all

[2]Underlined terms have an associated URL given in the Webography annex at the end of the article.

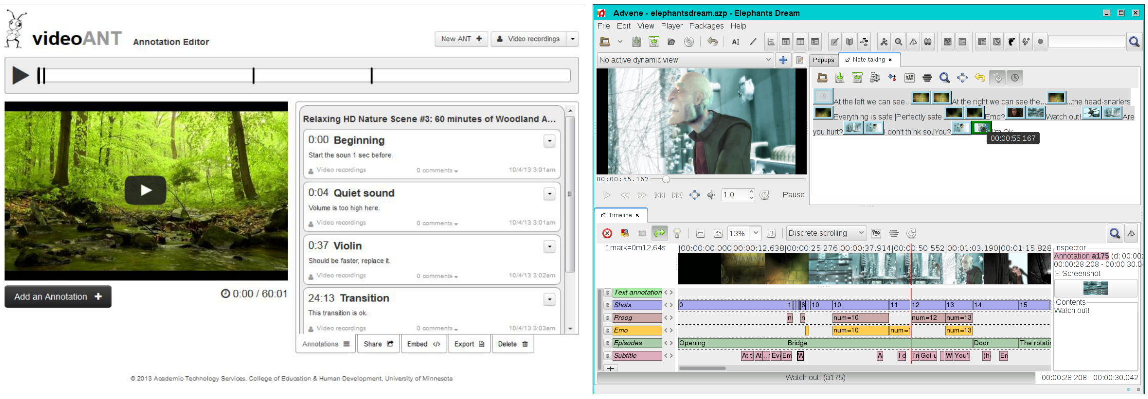

Figure 2: On the left, the VideoAnt video online annotation system displays the video with some annotations organised in a list. On the right, the Advene video annotation tool features several annotation display and creation interfaces: here a timeline at the bottom and a temporalized note-taking view on the right of the video.

offer annotation capabilities accompanied by various visualisation and analysis capabilities. **Pedagogy** is obviously an important domain for video annotation practices. First, any matter dealing with videos content as learning material, such as language or movie courses (Aubert and Prié, 2005; Puig and Sirven, 2007), can benefit from the usage of annotations on a course support, as in VideoNot.es. Second, discussion about self-reflective activities can be enhanced by annotation-based tools. For instance, VideoTraces has been used for a long time in dance courses (Cherry et al., 2003; Bailey et al., 2009) for annotating dance sessions. More generally, video recordings of learners presentations or interaction are used to implement self-reflection activities in classrooms (Rich and Hannafin, 2009), supported by a number of tools such as VideoTraces, CLAS or MediaNotes.

It appears that a great number of practices have been experimented in different contexts and application domains, from the 1990s VHS based reflective activities to the more recent collaborative and online video analyses. The experience accumulated on these tools and practices could fruitfully be incorporated in e-learning.

4 E-LEARNING PROCESSES BASED ON VIDEO ANNOTATIONS

In order to assess in what measure we can leverage the existing experience in video annotation systems in an e-learning context, we organize these processes along four classes of scenarios.

For **active reading with annotations**, video is a learning material whose content has to be assimilated or evaluated. This task is carried out through an iterative process, dedicated to the analysis of the audiovisual source through its enrichment with annotations and the definition of appropriate visualisations. In a learning context, students may annotate the video material by taking notes, by themselves or collaboratively. Conversely, teachers may use the same techniques for evaluating and grading videos produced by students. And both learners and teachers can engage into a discussion about a video through annotations.

Live annotation occurs during a live lecture, which is recorded and annotated at the same time. Students take notes during the lecture, and reuse these notes as a basic indexing system when replaying the recording. Teachers may also let students ask questions through annotations, and answer them at the end of the lecture (Bétrancourt et al., 2011).

Performance annotation also implies video as a trace of a performance, be it recorded in a conventional classroom or during a synchronous online session. The recording may already be augmented automatically by the capture of annotations containing information about the activity (sent documents, chat messages, etc). Based on this recorded video and activity trace, students may annotate their own performance, for self-reflection or for sharing an analysis with their teacher (Rich and Hannafin, 2009). Teachers may as well annotate their own performance in a self-reflective way, to improve their practice (ibid). Eventually, students may annotate a recorded course for suggesting improvements or pointing out difficult sections. The teacher can use that feedback when preparing the next course or the next version of the same course (Sadallah et al., 2013).

Eventually, in **annotation for assignment**, the video is a material that has to be used to prepare an assignment (a feature movie, a recording of new for media analysis, etc). The work may require students to analyse some aspects of the video, and produce annotations reflecting their analysis. The annotations are then later assessed by the teacher (Wong and Pauline, 2010). Further, the annotations resulting from the analysis may be reused to produce a new document, like an abstract or a video collage. At Columbia University, students use the MediaThread platform (Bossewitch and Preston, 2011) to produce critical video composition or critical multimedia essays, by combining annotations. The teachers then assess their productions.

We can identify distinguishing features between these different classes of scenarios, considering on the one hand the status of the video, and on the other hand the actors producing and using the annotations. The annotated video can be a base learning material, such as a movie or a documentary to study, or can be a recording of a lecture (which the students may or may not have seen live). It can also be the recording of student contributions. The actors producing and/or using the annotations can be the students, the teachers, student colleagues or teacher colleagues, or even the general public.

5 ANNOTATION USES IN E-LEARNING SYSTEMS

Table 1 provides an overview of the various functionalities related to video annotation offered by mainstream MOOC platforms[3] or more specifically dedicated tools.

From our analysis, it appears first that features that facilitate the comprehension of the discourse - such as the possibility to adjust the video speed or activate subtitles and transcriptions - are largely present in MOOCs. These tools seem to be important in a multicultural context where subtitles or transcription are frequently produced in collaboration with student in the case of translations to other languages. Second, there is the use of interactive enrichments in MOOC platforms, usually to have the video stop so that students answer a question in order to verify the understanding of what had just been explained. Third, if many MOOC platforms allow adding comments on video lectures, annotations refering to a part of the video are only possible via external tools. Fourth, the dedicated tools we analyzed offer more features regarding the annotation process - such as interactive timelines, export of annotated data, sharing of annotation, etc. - than MOOC platforms.

Thus, most of the solutions presented in Table 1 provide the possibility to develop pedagogical activities aiming to achieve active reading with annotation from students. Indeed, this is the main use of such tools by MOOC students, who are seeking a better understanding of the proposed video material. Annotation-based active reading can be carried out individually as well as collaboratively in the majority of the tools. This last possibility is even more significant: as students cannot always rely on having their doubts/difficulties solved by the teacher, collaboration with peers via annotation tools can increase their understanding along with secondary benefits of developing cognitive capacities on learning from video, observational skills and increasing focus and attention.

As far as our other classes of scenarios are concerned, performance annotation was not observed in the MOOC context although it could lead to an improvement of courses as it would be based on facilitated self-reflection for the teacher or, even better, if made in collaboration with students. Tasks involving annotation as assignment were not observed either, though it is clear that the possibility of critical exploration where students must find evidences to support their thinking could be used within the MOOC context, even so with the use of external annotation tools and peer evaluation (a well developed practice already used regarding text assignments).

6 SOME CHALLENGES

It appears that video material and its use in MOOCs are massive nowadays; nevertheless a more advanced use of video enrichments and more specifically of video annotations is still not a reality. From the classes of scenarios we described earlier and the overview of the current situation of e-learning and MOOC platforms, we would like to put forward a number of challenges that we think should be addressed in future versions of e-learning systems, linked with annotation issues.

Manual Production of Annotations. Manual annotation processes raise specific ergonomic and usability issues, all the more in the video domain where playing the document may interfere with annotation entry. The variety of targeted devices like mobile phones exacerbates these issues. Moreover, as mentioned above, annotations are also an ideal vehicle for collaboration activities around videos, in a synchronous (Nathan et al., 2008) or asynchronous way.

[3] Based on courses available in late December 2013. Some platforms such as Udemy were not considered due to the fact that they do not have an open access. This table will be actualized for the final version of the paper. A more detailed version is available on the web and constantly actualized on http://comin-ocw.org/video-annotations/platform-features/.

Table 1: Annotation-related functionalities offered by mainstream MOOC platforms or dedicated tools.

		EdX	Coursera	Canvas Network	Khan Academy	Iversity	Open2Study	VideoANT	VideoNot.es	Annotated HTML	Mediathread	YouTube	Matterhorn Player
Visualization	**Multilanguage subtitles**		X[1,2]	X	X[1]	X	X					X	X
	Transcription	X	X	X	X		X					X	
	Other synchronized enrichments (e.g. slides)												X[3]
	List of annotations (navigable)							X	X	X			X
	Timeline with annotations							X					X
	Interactive enrichments on the video or aside (e.g. embedded questions, alternative endings, hypertext links to external content)		X[4]		X[4]							X[5]	
Editing/sharing features	**Comment** (about the whole video)	X			X	X					X	X	X
	Video markers (single timecode + comment)	X[6]			X[6]		X[6]	X	X	X		X	X
	Internal annotation tools (natively on the platform)							X	X	X	X	X	X
	External annotation tools[7] (third-party tools)	X	X[8]		X							X	
	Exportation of temporalized data							X	X				
	Internal annotations sharing							X			X		
	External annotations sharing[9]							X	X				

Notes: **1**. Usually generated automatically with the possibility of correction by the students. **2**. Translations into other languages are carried out in collaboration with students (crowd sourced translation). **3**. Synchronized slides. **4**. Use of multiple choice embedded question. **5**. Video Questions is a new feature available in beta version. There is also a possibility to choose the ending of a video. **6**. Navigation of the video through transcriptions. **7**. Usually VideoNot.es, those are the platforms featured on its website. **8**. The use of the tool is promoted on the Coursera wiki page. **9**. In most cases, videos on YouTube can be used by the external tools.

This brings some specifics issues, notably around the ergonomics of video co-annotation; as well as privacy (e.g. the level of shared information must be clearly displayed and tunable by users).

Semi-automatic Generation of Annotations. Most video-based e-learning systems use only plain videos, sometimes fragmented into small independent videos, providing only basic features. In order to make these videos more accessible, e-learning platforms should commonly provide features such as transcription or chaptering. Some projects such as TransLectures aim at providing automatic or semi-automatic transcription of video, so that users may use the transcription as entry points into the video, either for querying and finding specific fragments, or as a simple navigation means.

Rich Media and Hypervideos. Beyond the basic video layout (side to side, overlay) that can be used to display the video material, annotations can be used to enrich the video or to produce whole new documents, such as hypervideos (Chambel et al., 2006) that are documents combining video and assets originating from annotations. Challenges here pertain to ergonomics, document modelling and (semi-)automatic production, for instance through an annotation-guided summarization.

Video Annotations Related Learning Analytics. With MOOCs, learning analytics have become a major concern for all organisations, by necessity - on this kind of scale, it is important to take informed decisions - and by opportunity - we now have the technological and processing capacity to capture and analyse the huge amount of information generated by thousands of learners. The annotation process and the annotations themselves offer an additional source of information for learning analytics at a finer scale, that could qualify as micro-analytics. Given the importance of video resources, it is undoubtedly important to have precise feedback on its reception. This new source of information could be used for example in course re-engineering (Sadallah et al., 2013).

Annotation Model and Sharing. Numerous tools provide video annotation features, and many use custom data models for storing annotation information (Cinelab, Exmeralda). However, standardization efforts are underway to define more interoperable and generic annotation models, able to encompass various annotation practices on different source documents and to integrate well with the current semantic web efforts (OpenAnnotation). Let us remark that some universities, mainly in the US, are strongly committed to pushing forward and generalizing annotation practices among students and faculty members, building annotation ecosystems: Columbia (Bossewitch and Preston, 2011), Stanford (Pea et al., 2004) and Harvard.

All these challenges share common concerns. First, mobile phones and tablets have become important platforms for consulting various resources, and among them, pedagogical resources. It is important to propose the most complete experience on annotation-enhanced e-learning platforms on all devices, and especially on mobile ones, which have important constraints in terms of display size and general capacity. Second, copyright and licensing issues are even more stringent, since they concern not only the video document (which has to be shareable to allow collaborative work), but also the produced annotations. Clear licenses for this additional data should be specified, hopefully with a bias towards openness and reuse. Eventually, the question of accessibility - mainly for sensory deficiencies - has to be considered as video annotations are clearly a means to provide a better level of accessibility to video content (Encelle et al., 2011).

We have proposed four classes of scenarios illustrating how video annotations can be used in e-learning contexts. To evaluate in what measure these scenarios are feasible or already present, we have reviewed a number of e-learning platforms (focusing on MOOCs) and tools, in order to identify existing annotation features. It appears that if some support already exists, there is still plenty of room to efficiently implement the scenarios that go beyond simple active reading, and a number of challenges related to video annotation still remain. These challenges should be addressed in future versions of e-learning systems, and we will tackle some of them in our future work on the COCo platform[4].

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[4]The authors of the paper are involved in the COCo project (Cominlabs Open Courseware) based in University of Nantes, which is a recent initiative of the Cominlabs laboratory. The project goals are to build and animate a research platform for both disseminating and promoting rich media open courseware content.

A WEBOGRAPHY

You will find here the URLs referenced in the article, in alphabetical order. Due to editing limitations, they could not be included as hyperlinks in this version. The version of the article on the author's website http://www.comin-ocw.org/ has them properly hyperlinked.

Advene: http://www.advene.org/
Annotated HTML: http://www.stanford.edu/group/ruralwest/cgi-bin/drupal/content/building-annotated-video-player-html
Anvil: http://www.anvil-software.de/
CLAS: http://isit.arts.ubc.ca/support/clas/
Canvas Network: https://www.canvas.net/
Cinelab: http://advene.org/cinelab/
Cominlabs Open Courseware: http://comin-ocw.org/
Coursera wiki page: https://share.coursera.org/wiki/index.php/Third-party_Tools
Coursera: https://www.coursera.org/
EdX: https://www.edx.org/
EliteSportsAnalysis: http://www.elitesportsanalysis.com/
Exmeralda: http://www.exmeralda.org/
Harvard: http://annotations.harvard.edu/
Iversity: https://www.iversity.com/
Khan Academy: https://www.khanacademy.org/
Matterhorn Player: http://opencast.org/matterhorn/feature-tour/
MediaNotes: http://www.cali.org/medianotes
Mediathread: http://mediathread.ccnmtl.columbia.edu/
MotionView Video: http://www.allsportsystems.com/
Noldus: http://www.noldus.com/
Open2Study: https://www.open2study.com/
OpenAnnotation: http://www.w3.org/community/openannotation/
Transana: http://www.transana.org/
Translectures: http://www.translectures.eu/
VideoANT: https://ant2.cehd.umn.edu/
VideoNot.es: http://www.videonot.es/
VideoNot.es: http://www.videonot.es/
VideoTraces: http://depts.washington.edu/pettt/projects/videotraces.html
VideoTraces: http://depts.washington.edu/pettt/projects/videotraces.html
YouTube: http://www.youtube.com/
Yovisto platform: http://www.yovisto.com/

Writing Aid Dutch

Supporting Students' Writing Skills by Means of a String and Pattern Matching based Web Application

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Keywords: Electronic Writing Aid, Higher Education Students, Writing Skills Development.

Abstract: Students at universities and colleges in Belgium and abroad often experience difficulties with writing (academic) texts in their native language (De Wachter and Heeren, 2011; Dugan and Polanski, 2006; Gray et al., 2005; Napolitano and Stent, 2009). This is reflected in many initiatives that are being developed specifically to support students' writing skills, among other the development of electronic writing assistance systems. Many of these systems are based on Natural Language Processing techniques, such as parsing. In this paper, we will argue that writing aids do not always have to make use of NLP techniques in order to analyze texts in a detailed and accurate way. We present an online writing aid, Writing Aid Dutch, which marks possible areas of concern in students' texts on three levels: (1) text structure and cohesion, (2) style and (3) spelling and provides users with individualized feedback. Writing Aid Dutch uses a lot of data and analyzes texts using complex queries and string matching techniques. Initial user experiences have been very positive so far. From February 2014 onwards, the effectiveness of the writing aid will be investigated in a one-group pre-post test design.

1 INTRODUCTION

Students at Flemish universities and colleges often have difficulties with writing, irrespective of the educational field they are in (Berckmoes and Rombouts, 2009; Berckmoes et al., 2010; Bonset, 2010; De Vries and Van der Westen, 2008; De Wachter and Heeren, 2011; Peters and Van Houtven, 2010). In 2011, a quantitative and qualitative needs analysis carried out among first year students of KU Leuven (Belgium) revealed that the most frequent writing problems of students are situated on the level of (1) text structure and cohesion, (2) style and, to a lesser extent, (3) spelling (De Wachter and Heeren, 2011). The results of this needs analysis are strikingly similar to those of previously conducted studies in Flanders as well as abroad.

The concern of students' poor writing skills is not confined to Belgium alone but is shared internationally and has already resulted in many initiatives offering writing support for students (Taylor and Paine, 1993; Gray et al., 2005; Dugan and Polanski, 2006; Graham and Perin, 2007). Among other things is the development of automatic and semi-automatic writing aids. Desktop applications such as SWAN (Scientific Writing AssistaNt, Kinnunen et al., 2012) or web applications such as the Language Tool Style and Grammar Checker (Naber, 2014) or Spell Check Plus (Nadashi and Sinclair, 2014) offer writing assistance to students who write at an L2 level or in their native language. These tools often use NLP techniques, such as a parser, to analyze the inserted texts in a detailed way.

Many of the writing assistance systems available today are able to provide students with useful and accurate feedback on different aspects of their text. However, despite the good intentions that they have, some of these writing assistance systems have some drawbacks as well. In the first place, the accuracy of the suggested feedback or corrections is not always satisfactory. Secondly, some of these writing aids, such as Scientific Writing AssistaNt, are rather time-consuming as students have to pass several 'stages' before receiving any feedback on their text. Moreover, SWAN provides the user with an overwhelming amount of information, which makes that he loses sight of the relevant feedback. This reduces the feeling of being responsible for your own writing product as well. Contrary to that, many web-based writing aids provide too limited feedback, which leaves the user frustrated and unsatisfied. Lastly, many writing aids concentrate too little on the writing process and do not encourage students' writing skills development, because they immediately suggest corrections (Napolitano and Stent, 2009).

In this paper, we present an online writing aid, the Writing Aid Dutch, a web application that responds to the strong need for effective writing support in Dutch. The writing aid analyzes texts, using string and pattern matching techniques to identify errors but also possible areas of concern in the submitted text. Based on the results of several needs analyses, the didactic purpose of the writing aid is to raise students' awareness on frequent writing problems that are situated on the level of (1) text structure and cohesion, (2) style and (3) spelling (Berckmoes et al., 2010; De Wachter and Heeren, 2011; Peters and Van Houtven, 2010). The writing aid does not correct and 'judge' students' writing mistakes, but marks them in the text and provides students with concise feedback, tips, examples and links to informative websites. Students can submit different genres of texts into the writing aid, such as a report, paper, essay, articles or master thesis.

In what follows, we will discuss the design and metrics of the writing aid after a short section on related work. We will then report some first user experiences and discuss future work, before we turn to our conclusions.

2 RELATED WORK

The development of Writing Aid Dutch fits in with an international trend of responding to students' writing problems with the development of electronic writing assistance systems. More specifically, it corresponds to the attention shift from product assessment to process-oriented support (Dale and Kilgarriff, 2011; Fontana et al, 2006; Gikandi et al., 2011). Writing assistance systems such as Amadeus (Fontana et al., 2006) or Helping Our Own (Dale and Kilgarriff, 2011) are specifically being developed to assist students throughout their writing process.

The underlying NLP techniques that these writing assistance systems use, however, differ from the data and string and pattern matching techniques that are implemented in Writing Aid Dutch. Apart from SOS-Frans ("SOS French") (Rymenams et al., 2012), a writing aid aimed at non-native speakers of French that has been developed at the same institute as Writing Aid Dutch, there is no knowledge of writing aids that do not make use of NLP techniques.

3 WRITING AID DUTCH

3.1 Interface

The interface of Writing Aid Dutch is simple and user-friendly: after students have copy-pasted or keyed in their text in the input field, they can click on three coloured buttons that each represent one of the three problem areas: (1) text structure and cohesion, (2) style and (3) spelling. These buttons are connected with arrows indicating the preferred order in which students should check the text. However, the student remains free to click on the button they prefer. As such, a learning path is suggested but students are free to determine their own pace in that they can choose which analyzed elements they want to look at first and when they want to take another step. The environment of Writing Aid Dutch is strongly user-controlled, seeing that our students are rather advanced learners and therefore do not need maximal guidance. Moreover, a system that is fully program-controlled would reduce the motivation of our students.

Figure 1: The three buttons 'Structure and cohesion', 'Style' and 'Spelling' on which students can click.

Considering that the writing tool is being developed for Dutch native speakers, feedback is in the form of general advice that is deliberately kept concise in order not to reduce students' motivation. For some of the text elements marked in the text, additional information is given in small pop-up screens that appear when the user scrolls over a highlighted text element, or in an extra field when students click on 'read more'. The illustration below gives a screenshot of text analysis and feedback for the use of structure words. When the user scrolls over a marked structure word, its meaning is provided in an extra pop-up field: in the illustration below, the meaning *tegenstelling* "contrast" is given for the structure word *echter* "however".

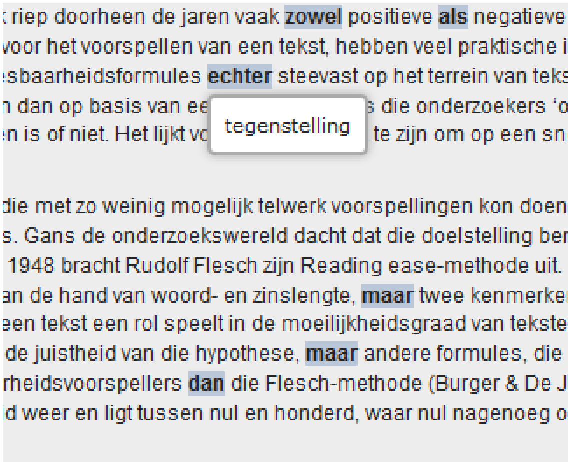

Figure 2: Marking of structure words under 'Structure and cohesion'.

3.2 Metrics and Implementation

In each of the three levels, students can check specific textual elements or metrics that are related to it. In the following sections, the individual metrics of each level and the data involved will be described.

3.2.1 Level 1: Text Structure and Cohesion

In the level of text structure and cohesion the student can check (1) use of reference words, (2) use of structure words, (3) most frequent words of the text, (4) recurring sentence patterns, (5) sentence length and (6) paragraph length. More general statistics concerning text structure and cohesion, viz. the total number of words, sentences and paragraphs of the text are given as well. Lastly, the readability index (or complexity index) of the text is calculated.

Reference words and structure words are highlighted in the text by matching the text with lists of words. For the third metric, namely that of the most frequent content words of the text, the text is matched with a frequency list containing word forms of only content words. The word forms that are found in the text are lemmatized, and these lemmas are displayed to the student. As far as the next metric of recurring sentence patterns concerns, there is no specific measure. We have worked as follows: sentences that start with *de* "the", *het* "the", *een* "a", *die* "those", *dat* "that", *deze* "these", *dit* "this", *men* "one", *er* "there" point out to few variation in sentence construction. If more than two sentences in five start with these words, they are marked. This formula applies to other recurring words as well. For the last two metrics, sentence and paragraph length, a minimal and maximal boundary is set: sentences containing less than 8 words and more than 30 words are marked; the boundaries of the paragraphs are set at respectively 4 and 17 sentences per paragraph. For these two metrics, the average sentence and paragraph length is calculated and visualized through a small traffic sign, displaying a red ("too long/short sentences/paragraphs"), orange or ("possibly too long/short sentences/paragraphs) green ("sentence and paragraph length confirms to norm") light.

The readability index that is calculated is partly based on the Flesch-Douma formula, the readability formula based on Flesch (1948) but adapted to Dutch, which predicts a text's readability by taking into account word length, i.e. the number of syllables per word, and sentence length, i.e. the number of words per sentence. Despite a number of objections, such as the idea that long sentences are not always more complex than shorter ones (Jansen and Lentz, 2008), this formula has proven to be a reliable predictor of a text's readability and complexity. However, to make the formula even more accurate we have added word frequency, seeing that words that are highly frequent are more understandable than infrequent words. We use a frequency list consisting of word forms instead of lemmas.

3.2.2 Level 2: Style

The metrics distinguished in the second level are (1) use of passives, (3) use of nominalizations, (3) personal language use, (4) long-winded constructions, (5) informal and subjective words, (6) formal and archaic words, (7) vague words and (8) word combinations. For each of these metrics, Writing Aid Dutch checks whether the style of the inserted text is adapted to the required norm. Seeing that the students who use the writing aid come from different institutions (university or college) and, as a consequence, write in different text genres, the writing aid does not 'judge' the inserted text but provides the student with nuanced information about these different style requirements. Again, most of the metrics in this level are highlighted in the text by string and pattern matching.

3.2.3 Level 3: Spelling

The last level on which students can check their text is spelling, where typing mistakes and wrongly spelled words are marked by a spell-checker. The use of abbreviations is checked as well.

The implementation of the spell-checker has been (and still is) a labour-intensive work. The spell-checker is based on a word list containing over seven hundred thousand words forms that is still being completed. The database word list contains headwords supplied with linguistic information such as word class, article, plural form, past form, participle etc. In total, fifteen word classes are distinguished.

The spell-checker functions in various steps. The process starts by distinguishing every word separately, defining its boundaries by marking the spaces and punctuation marks and as such splitting up the sentence. After sentences are subdivided into separate words, occurrences of more or less fixed expressions are first of all being looked at. The database contains a list of these expressions, especially archaic phrases, which is matched with the text. A second step checks whether the remaining unrecognized and single words are in the word list. When this is not the case, the word will have to pass several conditions before it will be marked as wrong. In what follows, we will describe some of these conditions.

A first condition comprises combinations of numbers followed by a special character that are allowed in academic papers, for example "5°" or "10%". A second condition refers to other symbols that may occur as well, such as Roman numbers like "I", "IV" or "XI". For the third and the fourth criterion, it is important to note that Dutch is a compound language in which words can very easily be composited. Compounds in Dutch are always written in one word or with a hyphen. The third selection criterion then concerns compound words that are written with a hyphen and consist of words that also exist on their own, for example a word such as *adjunct-directeur* "adjunct-director". The fourth condition picks out compounds written without a hyphen. In this step, two functions are used to reduce the number of possibilities. A first one splits up a word, for example the word *strooizout* "road salt", in the following manner:

```
s/trooizout
st/rooizout
str/ooizout
stro/oizout
stroo/izout
strooi/zout
```

The function stops when both queries give a valuable result, in this case *strooi* and *zout*. The minimal length for a word to be recognized is fixed at four characters, seeing that fewer characters resulted in too many false positives, i.e. words that do not exist but are nonetheless grammatically correct. A second function in this condition relates to the syntactic place that a particular word can have in a compound, namely in the beginning or at the end of the compound. This is statistically determined on the basis of the word list. For each syntactic option, frequency is calculated. For example, *achterover* "back" can never occur at the end of a compound but occurs, so far, a hundred and nine times in the beginning of a compound word, like in the verb *achteroverleunen* "to lean back". In the fifth step of process, the spell-checker looks at a list containing named entities. When a word, then, still has not been found, the context is taken into account in order to check whether the word is part of a word group that has not been recognized as a fixed expression. Concretely, the context is limited to a span of four words left and right.

When a word still has not been recognized after these selection criteria, it will be marked red in the students' text. However, a word can also be marked blue in the text. For these words, the spell-checker suggests an alternative form, based on the Levenshtein distance principle. This principle tries to alter one string into another string by making minimal changes, for example by changing or deleting one letter. The spell-checker is designed in a way that it is partly self-supportive. Unrecognized words automatically appear in a separate database, so that they, in the case of correct words, may be added later to the spell-check word list.

3.3 Comparison to Word Processing Software Such as Microsoft Word©

In Microsoft Word© grammar and spelling can be checked in a variety of languages, among which is also Dutch. A comparison between Microsoft Word© and Writing Aid Dutch seems therefore relevant. With regard to the computational implementation, language-specific information in Writing Aid Dutch cannot, unlike in Microsoft Word©, be considered as a rule set that is imported in the system. In the spell-checker of the writing aid, for example, many of the hard codes are only applicable to Dutch. An example is the following part of a code:

```
if(alleen_in_samenstelling($woord)
```

The part *alleen in samenstelling* "only in compound" relates to complex verbs in Dutch such as *tekeergaan* “to rant”. The part *tekeer* does not exist on its own but always occurs in combination with the verb *gaan* “to go”; as a consequence, *tekeer* will not be marked wrong because it is part of a complex verb. However, the codes that are used in Writing Aid Dutch to refer to its underlying databases can easily be adapted to other languages; only the databases itself will be different.

Because of the many complex and language-specific codes, the spell checker of Writing Aid Dutch is much more accurate and complete than the Dutch spell checker in Microsoft Word©. Checking grammar has never been a priority in the development of Writing Aid Dutch, seeing that its target audience are advanced native speakers of Dutch.

4 FUTURE WORK

4.1 Text Analysis on Content Level

At the moment, we are also experimenting with more content-oriented text analysis by categorizing certain words that appear in a student’s text into semantic fields. For this experiment we have used texts of KU Leuven students of Political Science, in which they had to compare two politicians. By identifying these words that express either similarity or difference in the text, the distribution of these two semantic categories is revealed, so that it can be investigated if they appear equally and at the right place in the text. Another experiment is the identification of academic words or more technical terminology in the text.

4.2 Effectiveness Analysis and Further User Study

From February 2014 onwards we will investigate the effectiveness of the writing aid in a quantitative and qualitative one-group design study. Despite the fact that such a design has minimal internal validity and no external validity (Sytsma, 2002), we have chosen this design because of time restrictions of the project. A within-subjects design does not require a placement test that cancels out possible differences in competencies between participants (de Smet et al., 2011). A total number of minimal 60 students of university as well as college institutions will be tested. On the one hand, effectiveness will be measured by rating texts written without and written with Writing Aid Dutch. On the other hand, students’ as well as teachers’ perception of the learning progress will be evaluated. The results of the effectiveness experiment will be available in June 2014.

A tool that is similar to Writing Aid Dutch, SOS-Frans, has been developed at the KU Leuven for French as a second and foreign language and turned out to be very effective, leading to fewer mistakes (Rymenams et al., 2012). Scientific Writing AssistaNt, reduced the lack of structure and semantic coherence in scientific papers (Kinnunen et al., 2012). Moreover, as teachers, we have already experienced noticeable progress in papers of students when they use Writing Aid Dutch. By analogy with similar writing aids and on the basis of our experiences, we hypothesize that the learning-process of students who use the Writing Aid Dutch will improve and that their writing products will be better.

As mentioned in Leakey (2011), the empirical data that result from quantitative research should ideally be completed with judgmental data. We have already gathered initial user experience by means of an online questionnaire filled in by 50 students. Next to students, 10 teachers of several faculties have reported their experiences in focus interviews. However, these data are not sufficient and we will carry out extra questionnaires and focus interviews with students and teachers as part of our effectiveness study.

5 CONCLUSIONS

In this paper, we have presented the Writing Aid Dutch. We have shown that the implementation of NLP techniques is not always a prerequisite for the development of appropriate computer-based support. Text analysis based on string and pattern matching techniques can be detailed, correct and fast. The writing aid (1) raises students’ awareness of frequent writing issues, (2) provides clear and individualized feedback, tips and examples, (3) focuses on the process, (4) has a simple and user-friendly design and (5) leads to less ‘shallow’ and repetitive correction work for lecturers. As a web application, the writing aid is a durable and partly self-supportive tool that can be adapted at any time.

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A New Method for the Creation of MOOC-ready Database of Test Questions

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Keywords: Formative Assessment, Massive Open Online Course (MOOC), Engineering Education, Distance Learning, e-Learning, Training, Digital Circuit Design, Combinational Logic.

Abstract: Recently, there has been a wide interest in the massive open online courses (MOOCs) that are freely available to the students from all over the world. Due to the large scale of MOOCs, the instructors (even with their teams of graders) cannot assess all the examinations and quizzes themselves. Peer grading eases the assessment burden but has its shortcomings. Ideally, the assessments should be fully automated and should also allow partial grading. Additionally, a sizeable database of questions is needed so that an individual student or a group of students are not able to see all the questions by repeatedly attempting the quizzes. In this paper, we present a Matlab-based method for automatically generating a large number of questions and their (intermediate and final) answers for a MOOC or a traditional classroom-based course on digital circuit design. The method that enables formative assessment is also applicable to other courses in engineering and sciences.

1 INTRODUCTION

Different methods of distance learning have existed for many years. Short video tutorials were popularized by Khan Academy (Anon, 2014f) that was founded in 2006, while fully online courses have been offered by some universities since 2008 (Koller, 2013). One of the first *massive open online courses* (MOOCs) offered by the University of Illinois, Springfield, was attended by more than 2500 students, in 2011 (Anon 2011). TED and iTunesU (Anon ,2014e) also came about in the same timeframe.

MOOCs became very well-known after more than 100,000 students signed up for a Stanford University course. A large number of full-length courses are now available through different sources for millions of students enrolled from all over the globe (Frank, 2012; Mitros et al., 2013).

The popularity of MOOCs is driven by the no-cost availability of the course content. Unlike traditional courses, there are no enrolment limits for the students and there are relatively low requirements on faculty facilitation after a course has been *developed* (Briggs, 2013).

Currently, Coursera (Anon, 2014c), Udacity (Anon, 2014h), and EdX (Anon, 2014d) are three major sources of MOOCs albeit with different missions, strategies, and tactics. Coursera's offerings mainly come from a few select universities inside and outside the US. Their upper-level courses are somewhat specialized. Udacity has used rather elaborate production methods in the course preparation and delivery; the courses are for lower-level maths and science, and are relatively few in numbers. EdX's offerings fall somewhere in between Coursera's and Udacity's.

The popular learning management systems such as Blackboard (Anon, 2014a) and Canvas (Anon, 2014b) have also jumped the MOOC bandwagon.

While MOOCs *democratize* the learning, they tend to deviate from traditional in-class courses in many respects. Due to the sheer number of course enrolees, they present a set of challenges never encountered before. The challenges lie in the areas of course design, delivery and assessment (Daradoumis et al., 2013).

One of main challenges for MOOCs has been the impracticability of human review of individual student learning progress and the assessments (Fournier, 2013). So the student work, including quizzes, have been either computer-graded or assessed by the peers. Automatic grading, understandably, has so far been limited and

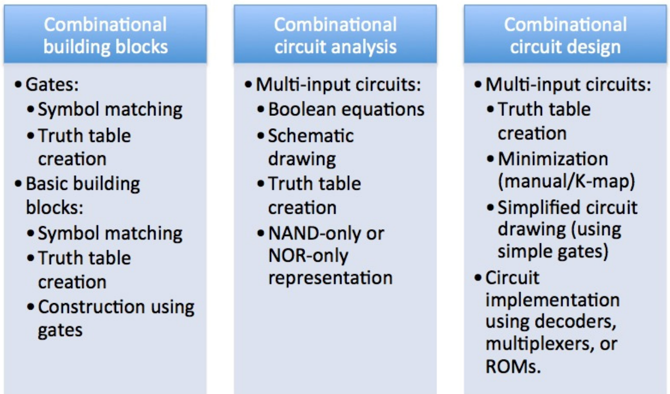

Figure 1: Combinational logic topics and the mechanisms for assessing them.

insufficient in nature. For student assignments that involve mathematical proofs, detailed designs, and essays, evaluation and proper feedback still remain the stumbling blocks. These lacunas in the assessment process are some of the hurdles in MOOCs being accepted as *for-credit* courses (Briggs, 2013; Miranda et al., 2013).

Many MOOCs have, to some degree, relied on peer-grading as an assessment tool. However, such grading is fraught with issues, such as the grader's bias due to his/her own performance, and possibly large differences in the graders' and the gradees' cultural and lingual backgrounds. How much time a grader spends on grading also comes into play (Piech, 2013). Providing rubrics to the graders helps achieve some degree of uniformity (Sandeen, 2013).

In this paper, we provide a mechanism for making the online assessment more effective while retaining automation. This is done by creation of a large number of test questions that are suitable for formative assessment. This set of questions can be utilized for a very large number of cohorts. The questions also allow checking of intermediate as well as final answers. Although our method is applicable to many courses in science and engineering, we will cover examples mainly from a course in electrical/computer engineering.

2 TACKLING THE ASSESSMENT CHALLENGE

Having an effective assessment is crucial for the ultimate acceptance of MOOC as a replacement of a traditional in-class course. Georgia Institute of Technology's recently proposed MOOC-based Master of Science (MOOMS) faces "a potential threat" from their evaluation system that would not fully assess, and would therefore "lead to an ineffective program" (Briggs, 2013).

Although having the students take proctored examinations is an option, it would incur some cost (vs. the completely free option) to the student.

Traditional test-banks accompanying the textbooks are mostly limited in size. Someone signing in with multiple accounts could repeat a quiz until he is able to get a perfect score. Therefore, the test-banks are not suitable for MOOCs' *class-sizes*.

Our proposed approach involves the use of Matlab (Anon, 2014g) for generating a very large number of questions and answers so that repeated attempts by a single person or by a group has little chances of seeing the same questions. We employ Perl CGI scripts to generate the webpages that display the problems and grade them automatically.

2.1 Assessment of a Course on Digital Circuit Design

In this section, we present the topics from a course that we have taught for several years, "Digital Design and Computer Organization."

One of the course *outcomes* is that the students are able to "analyze and design combinational circuits." The course topics related to the outcome are: logic gates, combinational building blocks, the analysis of combinational circuits, and the design of combinational circuits (see Figure 1). The last topic is the most complex of all, and entails a longer multi-step process. Obviously, for such as question, the grading based on a single, final answer is insufficient to provide effective feedback to a student. So partial grading should be done. Assessing the design problem conventionally requires step-by-step checking by a human grader.

2.1.1 Assessing Topic 1: Logic Gates and Combinational Building Blocks

The students are expected to learn about the symbols of different logic gates and combinational building blocks.

Examples of logic gates are INV, AND, NAND, OR, NOR, and XOR, mostly with 2 or more inputs. Assessing the knowledge of the gates involves matching the symbols with their names (not too complex of a task but essential in nature). The second type of questions require filling in of *truth tables* of gates with multiple inputs.

The combinational building blocks include decoders, encoders, multiplexers, etc. Besides many inputs, some of these blocks have multiple outputs. The assessment questions include building of the blocks with individual gates using a schematic entry module. The other type of questions includes completion of the truth tables for different blocks. See an example in Figure 2.

As one can see, by using the truth table entries and the schematic module, it is possible to both perform the partial grading and the checking of the detailed answers.

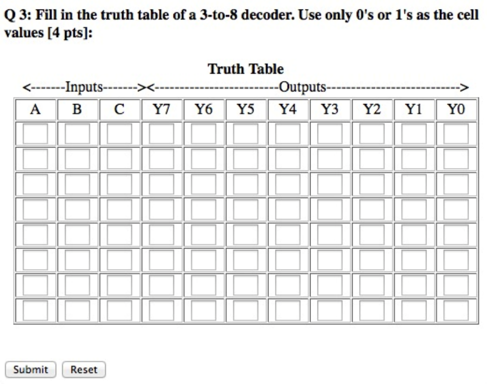

Figure 2: A sample problem for Topic 1: Filling in the truth table for a combinational block (3-to-8 decoder).

2.1.2 Assessing Topic 2: Analysis of Combinational Circuits

The learning expectations are met if the students are able to: (1) draw a simple schematic for a given Boolean function; (2) write the Boolean equation for a given circuit; (3) create a properly-sized truth table (i.e., dependent upon the number of inputs and output/s), and fill in the binary values; and (4) transform a circuit into the one that uses only the NAND or the NOR gates. A sample question generated with Matlab and presented (in online format) with a Perl script is shown in Figure 3.

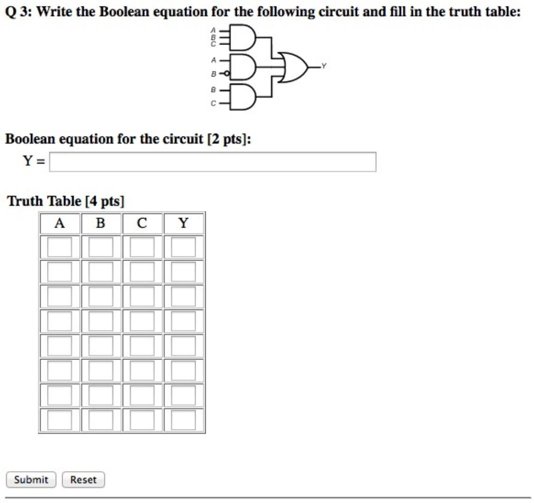

Figure 3: A sample problem for Topic 2: Combinational circuit analysis by writing the Boolean equation and completing the truth table.

2.1.3 Assessing Topic 3: Design of Combinational Circuits

The students taking this course should be able to design combinational circuits by: (1) creating a truth table that lists all combinations of inputs and output(s), (2) creating minimized Boolean functions using Karnaugh maps (K-maps), and (3) drawing the final circuit-schematic. The problems can also be descriptive in nature, but such questions would be limited in number, and hence not suitable for MOOCs. One of the solutions is to present problems that require minimization of a *sum-of-products* (SOP or sum-of-*minterms*) or *product-of-sums* (POS or *product-of-maxterms*). Using Matlab, we have created a very large number of problems (see the code in Appendix A), i.e., several thousand for three inputs, and a few million for four inputs.

A design example based on the *sum-of-minterms* and the *sum-of-don't cares* is shown in Figure 4. The students exhibit their knowledge of design by filling in the two tables and by typing in the final equation.

2.2 Evaluation of Question Database

We have seen signs of success with some initial use of the automatically generated tests. In the coming academic year, we are planning to fully utilize the question database in the Digital Design and Computer Organization in our university. The questions will be loaded in (the currently-used) BlackBoard learning management system.

Traditionally, during a given semester, we give

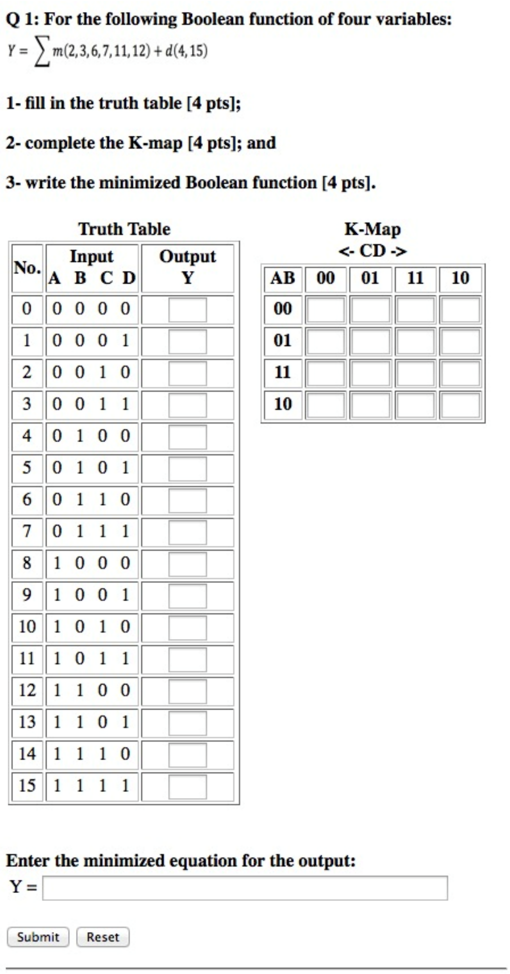

Figure 4: A sample problem for Topic 3: Design of a combinational circuit by (a) filling in the truth table, (b) using the K-map, and (c) writing the final minimized equation.

one quiz to the students on every topic of digital design. Due to the limited number of questions in our current test-bank, we have limited the test-attempts to one. With the availability of a much larger number of quiz questions, we will be able to offer the students some questions only for practice; no grades will be assigned for these questions. The number of quizzes would also increase; for each topic, the students may be allowed two attempts without exposing them to all the questions.

We will evaluate the effectiveness of our new database of questions by (1) comparing the upcoming semester's test-scores with the scores of the last four semesters', and (2) by conducting a student survey about the usefulness of the practice-quizzes in improving their understanding of different topics.

3 CONCLUSIONS

A new and powerful mechanism for creating assessment questions for a digital design course's combinational logic problems. Future applications of the method include question-generation for other topics in other courses taught at other institutions, in the traditional and the MOOC formats. Microelectronics, analog circuit design, and computer architecture are some of the courses in which the presented technique can be utilized.

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APPENDIX

The Matlab code for generating an exhaustive list of sum-of-minterms and sum-of-don't-cares for a given number of input variables is given in Figure 5a.

For three variables/inputs, a total of 3,248 different questions are generated, some of which are shown in Figure 5b.

```
nVar = 3;        % number of input-variables

N    = -1+2^nVar % maximum possible minterms
arrN = 0:N;      % array containing all minterms

% arbitrarily, between 50% and 80% of the values are "trues"
for sel = ceil(0.5*N):ceil(0.8*N)

   % select 'sel' terms from the arrN array
   minterms = combnk(arrN, sel);
   [rwMT tmp] = size(minterms);

   % for each set of minterms, vary "don't cares"
   for i = 1:rwMT

      % arbitrarily, up to 50% of 1's can become "don't cares"
      for doNotCareCount = 0:ceil(0.5*sel)
         mintermRow = sum_m(i,:);

         % use all combinations of "don't cares"
         arrDoNotCares = combnk(mintermRow, doNotCareCount);
         [rwDNC tmp] = size(arrDoNotCares);
         for j = 1:rwDNC

            % array of don't-care terms
            dontCareRow = arrDoNotCares(j,:);

            % final array of minterms
            finalMinTermRow = setdiff(mintermRow, dontCareRow);
        end
     end
   end
end
```

(a)

```
…
3202: y = sum_m (1, 3, 6) + sum_d (0, 2, 4)
3203: y = sum_m (1, 4, 6) + sum_d (0, 2, 3)
3204: y = sum_m (2, 3, 4) + sum_d (0, 1, 6)
3205: y = sum_m (2, 3, 6) + sum_d (0, 1, 4)
3206: y = sum_m (2, 4, 6) + sum_d (0, 1, 3)
3207: y = sum_m (3, 4, 6) + sum_d (0, 1, 2)
3208: y = sum_m (1, 2, 3, 4, 5) + sum_d (0)
3209: y = sum_m (0, 2, 3, 4, 5) + sum_d (1)
3210: y = sum_m (0, 1, 3, 4, 5) + sum_d (2)
…
```

(b)

Figure 5: (a) The Matlab script for generating an exhaustive set of sum-of-product equations, and (b) a sample set of 3-variable sum-of-product equations created by the script.

Methods and Technologies for Wrapping
Educational Theory into Serious Games

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Keywords: Game-based Learning, Serious Games, Instructional Design, Pedagogical Patterns, Critical Thinking, Argumentation Maps, Storyboarding.

Abstract: Although play does undoubtedly take a significant place in the development of human individuals and animals allowing for a manifold of risk-free exploration and experiment, contemporary serious games largely fail in meeting the high expectations of game-based learning. Educators know how to teach. Moreover, they know how to set up conditions, including approaches to playful education, in which learners can actively engage. In particular, experienced educators know how to adapt to a particular learner's needs, wishes and desires. But digital games including those named serious are computer programs. They do not know about didactics. There is a need for methods and technologies suitable to bring educational principles and pedagogical patterns into digital systems intended to enhance learning. The authors advocate the method of *storyboarding* and the technology of *storyboard interpretation* to wrap educational theory into e-learning systems, in general, and into serious games, in particular. Some comprehensive case study demonstrates the feasibility of this approach.

1 THE AUTHORS' POSITION

Edutainment started as a serious attempt to create computer games that taught children different subjects. Arguably, it ended up as a caricature of computer games and a reactionary use of learning theory.

[(Egenfeldt-Nielsen, 2007), p. 42]

Egenfeldt-Nielsen's critical view at serious games[1] is supported by a variety of critical studies such as, e.g., (Jantke, 2006) and (Jantke, 2007).

Apparently, the crux is "to get educational theory into serious games". This key issue is not particular to serious games, but applies to educational media, in general.

Latterly, some authors discuss the relevance of a few educational approaches to game-based learning (see, e.g., (Jin and Low, 2011), (Kirkley et al., 2011), (Leemkuil and de Jong, 2011)). Kirkley and his co-authors, for instance, investigate the way of getting a five-stage learning cycle[2] of problem-based learning perspectives (Duffy et al., 2009) realized in a certain serious game. The game play is discussed in much detail, but it remains largely open *how* to bring the educational theory into the digital system.

The present contribution is aimed at advocating the authors' following position.

> *Storyboarding is a methodology appropriate for anticipating user experiences of media interaction including game play and learning. Consequently, storyboarding is a methodology of didactic design.*

In accordance with (Jantke and Knauf, 2005), the authors exclusively consider digital storyboards. Digital storyboards may be easily manipulated by computer programs for purposes such as checking completeness and consistency, for instance.

Digital storyboards allow for going even further as expressed by the authors' supplementary position to be advocated by the present paper.

> *Storyboards may be interpreted algorithmically. Systems of e-learning, in general, and serious games, in particular, may run digital storyboards according to the educators' specification.*

The recent *storyboard interpretation technology* (see (Fujima et al., 2013) and (Arnold et al., 2013)) allows for experimenting with variants of educational principles and pedagogical patterns.

[1] See (Sawyer and Smith, 2008) for debating the concept.

[2] The topical literature is full of learning cycles ranging from John Dewey (Dewey, 1938) to David Kolb's Learning Style Inventory (Kolb, 1984) to ad hoc cycles in domains such as nursing education (Murphy et al., 2011).

2 BACKGROUND THEORY

Educational perspectives and theories are manifold. This position paper cannot afford any reasonable overview. Instead, the authors confine themselves to their application domain of critical thinking (Bassham, 2008; Fisher, 2006; Garz et al., 1999).

There is the crucial question of how to wrap, so to speak, the educational theory of critical thinking and moral reasoning into some serious digital game.

2.1 Kohlberg's Psychology of Moral Development

Kohlberg's substantial theory of moral development (Kohlberg, 1984) which was inspired by Piaget's approach (Piaget, 1932) is discussed as an example of a theory that views conscious moral reasoning as a central component of morality. Kohlberg's method to study the strength of moral judgment was quite simple. He used Piaget's story-telling technique to tell people stories involving moral dilemmas. He presented mainly children and adolescents dilemmas in which different moral factors conflicted. In each case was a choice to be considered, for example between the rights of some authority and the needs of some deserving individual who is being unfairly treated.

The most famous one is the Heinz dilemma: *A woman was near death from a special kind of cancer. There was one drug that the doctors thought might save her. It was a form of radium that a druggist in the same town had recently discovered. The drug was expensive to make, but the druggist was charging ten times what the drug cost him to produce. He paid $ 200 for the radium and charged $ 2,000 for a small dose of the drug. The sick woman's husband, Heinz, went to everyone he knew to borrow the money, but he could only get together about $ 1,000, which is half of what it cost. He told the druggist that his wife was dying and asked him to sell it cheaper or let him pay later. But the druggist said, "No, I discovered the drug and I'm going to make money from it." So Heinz got desperate and broke into the man's store to steal the drug for his wife.*

Kohlberg asked then a series of question, e.g.:

- Should Heinz have broken into the laboratory to steal the drug for his wife? Why or why not?
- Would it change anything if Heinz did not love his wife?

Kohlberg found that children from many cultures typically move through a sequence of levels and substages, although not everyone reaches a higher level of moral reasoning.

2.2 The Social Intuitionist Model (SIM) & Moral Foundation Theory (MFT)

The Social Intuitionist Model of moral judgment (Haidt, 2001) is a valuable contrast to the rationalist approach of Kohlberg, where moral reasoning is described as conscious deliberation. Haidt, instead, posits that moral judgment is mostly based on automatic processes–moral intuitions–rather than on conscious reasoning. People engage in reasoning primarily to find evidence to support their initial intuitions. Accordingly, the SIM is seen as prequel to the MFT.

Where does morality come from? Why does morality vary so much across cultures? Is morality one thing, or many?

In brief, the MFT proposes that six (or more) innate and universally availabale psychological systems are the foundations of intuitive ethics (Graham et al., 2011), (Graham et al., 2013)). These so-called moral foundations are characterized by unique conforming challenges, contents, triggering stimuli, virtues, and emotions. In Western cultures issues with Harm/Care and with Fairness/Cheating dominate. The moral foundation Harm/Care is triggered by suffering and distress, especially expressed by one's own kin. It's accompanied by the emotion of compassion. The Fairness/Cheating foundation deals with equality, cooperation, and deception. It's accompanied by the emotions anger, guilt and gratitude. Further moral foundations are: Loyalty/Betrayal domains regulate group cooperation through pride and anger. It underlies virtues of patriotism and self-sacrifice for the group. Whereas Authority/Subversion domains control hierarchies by recruiting the emotions respect and fear. It underlies virtues of leadership and followership. The Sanctity/Degradation domain is referring to food, health, and sexuality (thus conceiving the body as sacred). This foundation is mostly accompanied by feelings of disgust. The latest moral foundation is the Liberty/Oppression domain and deals with feelings of reactance and resentment of people toward those who dominate them and restrict their liberty.

2.3 Argument Mapping

In general, argument mapping (van Gelder, 2013) (see also (Twardy, 2004)) is described by means of diagrams which show the structure of an argument or of a set of arguments. Normally these are box-and-arrow diagrams (graphs in terms of mathematics, see section 4.4). Argument mapping is akin to other mapping procedures such as mind mapping and concept mapping, but it focuses on the logical, evidential or inferential relationships among propositions.

3 WRAPPING TECHNOLOGY

Quite intuitively and largely informally speaking, assume you adopt psychological and/or pedagogical positions to be implemented within some technology-enhanced educational framework such as a serious game. How do you make sure that your theory really works, i.e. it shapes the human-system interaction? In other words, how do you wrap, so to speak, the educational theory in e-learning systems, in general, and in serious games, in particular?

The authors' ultimate answer is *Storyboarding* à la (Jantke and Knauf, 2005).

3.1 Storyboarding Human Experience

Storyboarding means the organization of experience (Jantke and Knauf, 2005). To allow for an effective computational usage of storyboards throughout the process of design and implementation (see, e.g., section 3.4), storyboards are assumed to be digital. Conceptually, storyboards are finite, hierarchically structured, indexed families of finite, directed graphs.

Seen as a family of graphs, every storyboard is of the form $\mathcal{F} = \{\mathcal{G}_i\}_{i \in I}$, where I is any finite index set. For simplicity, one may assume $I = \{1, \ldots, k\}$, where k is any natural number indicating how many graphs belong to $\mathcal{F}$. Every individual graph $\mathcal{G}_i$ is of the form $[N_i, E_i, sub_i, c_i]$, where, as usual N_i and E_i denote the nodes and the edges of $\mathcal{G}_i$, respectively. The mapping $sub_i : N_i \rightarrow 2^I$ is assigning to every node a set of indices telling which graphs of the collection may be substituted for this particular node. Further, the mapping c_i assigns to every edge some condition of executability[3].

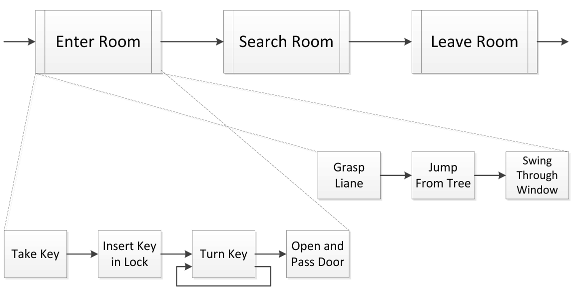

Figure 1: Illustration of Alternative Graph Substitutions.

[3]Due to the lack of space, all details of logics and logical reasoning are suppressed throughout the present paper. Variants of logics in use are discussed, e.g., in (Jantke and Arnold, 1996). Note, furthermore, that the present approach is slightly different from (Arnold, 1996), where constraints are not assigned to edges, but to nodes. The approach underlying the present paper is more expressive.

For the purpose of the present position paper, it is sufficient to understand storyboards as collections of graphs as exemplified in figure 1. Those nodes which may be subject to graph substitution are called *episodes*. Other nodes are called *scenes*. Every scene has some meaning in the domain such as showing some picture or playing some video, presenting some exercise to users, running an animation, and the like.

3.2 Layered Language of Ludology

(Lenerz, 2009) discusses the description of media experiences on different levels of granularity–the so-called *Layered Languages of Ludology*. Similarly, educational theory has varying levels of abstraction.

Storyboarding is an appropriate technology of top-down design beginning on high levels of abstraction.

3.3 Pedagogical Patterns

To keep it short, it is sufficient to know that the authors take the origins such as (Alexander, 1979) as well as modern ad hoc approaches toward the needs of digital games research such as (Björk and Holopainen, 2004) and (Jantke, 2012) into account. The unprecedented strength and clarity of formal approaches such as (Angluin, 1980) is preferred due to the intention to work with patterns algorithmically (Jantke, 2009).

This allows for dealing with pedagogical patterns described largely informally in everyday language (as in (Pedagogical Patterns Advisory Board, 2012), e.g.) more stringently using the graph-based storyboarding approach as adopted in the present publication (see (Jantke, 2013) for a more comprehensive study).

Pedagogical patterns are–with respect to above-mentioned *Layered Languages of Ludology*–lower level concepts. Patterns of learner activity may be represented as "smaller" graphs for possibly multiple usage, i.e. for substitution in different places.

3.4 The Technology of Digital Storyboard Interpretation

The so-called *Storyboard Interpretation Technology* is a very recent technological innovation published for the first time in (Fujima et al., 2013) and (Arnold et al., 2013). The essence of this novel approach is to make digital storyboards immediately executable. E-learning systems and digital games work like interpreters–a term and an operational understanding adopted from computer science–running, so to speak, on the storyboard. In doing so, the system checks at every scene how to interact with the human learner.

4 THE GAME-BASED LEARNING CASE STUDY "CATCH 22"

This section is intended to demonstrate the authors' positions by means of some practical application: the serious game "Catch 22". Wrapping technologies introduced in the preceding section have been deployed for a certain implementation surveyed in the sequel. Educational theory is reflected by some storyboard structures anticipating intended player experiences.

4.1 Underlying Educational Theory

Kohlberg did not ascribe moral development and moral judgment to innate factors, but rather attributed the transition between levels (pre-conventional, conventional, post-conventional) as driven by the opportunities afforded in everyday social interactions. Alteration may occur as a result of everyday role taking and change of perspective fostering empathy, or it may be driven by reflections about moral situations. Dilemma-discussion suits perfectly to encourage critical thinking, perspective changes and moral reasoning skills.

Haidt's SIM, in contrast, is understood as a social model in that it deemphasizes the private reasoning and emphasizes, instead, the importance of social and cultural influences. It states that moral judgment is a dual process, which is generally caused by quick moral intuitions, so-called automatic evaluations, and is followed (when needed) by slow, ex post facto moral reasoning, so-called effortful conscious mental activity.

According to (Haidt, 2001), the underlying SIM (see section 2.2) is visualized as in figure 2 below. The numbered links, drawn for Person A only, are

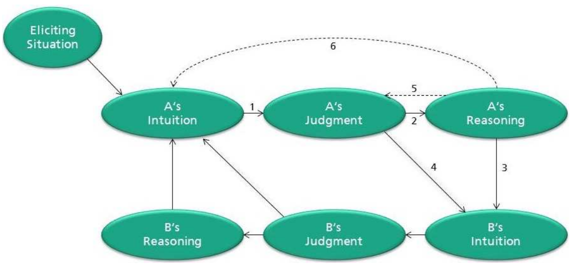

Figure 2: The Social Intuitionist Model of Moral Judgment.

(1) the intuitive judgment link, (2) the post hoc reasoning link, (3) the reasoned persuasion link, and (4) the social persuasion link. Two additional links are hypothesized to occur less frequently: (5) the reasoned judgment link and (6) the private reflection link.

4.2 Top-level Serious Game Design

We implemented Kohlberg's dilemma-discussion approach combined with Haidt's SIM in a digital game we called "Catch 22" to educate moral reasoning. For this purpose, we designed six dilemma-situations referencing the moral foundations mentioned in sec. 2.2.

The player wanders around in a 3D-world, has to solve quests and deals thereby with various virtual people who involve the player in moral dilemmas. The decision making process follows ad-hoc to the exposition and experience of the dilemma.

Target of the game is to enhance critical thinking skills and to raise awareness of the complexity of moral reasoning. For this purpose, the reasons and objections, which count for the chosen position, are structured and arranged in argument maps.

According to the authors' position advocated by means of the present paper, emphasis is put on the question how to wrap, so to speak, Kohlberg's and Haidt's theory into the digital system to be developed. Didactic principles underlying an e-learning design and implementation become structurally visible.

4.3 Wrapping Educational Theory Top-down

To wrap educational theory in a serious game like "Catch 22", it was necessary to grapple with game design.

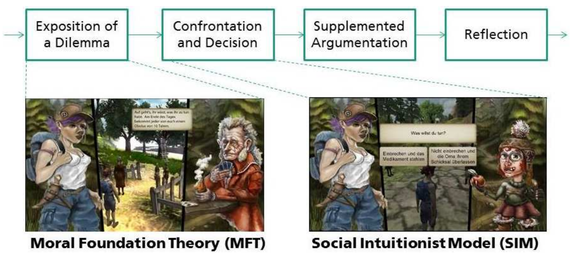

Figure 3: Some Excerpt from a High Level Storyboard of "Catch 22 " Experience of Game Play.

If and when people play games, they have an experience. It is this experience that a game designer cares about; because without the experience, the game is worthless. Experiences are so much part of human beings, they are hard to think about–even thinking about experiences is an experience. Although everyone is familiar with experiences, they are quite hard to describe. You can't see them, touch them, or hold them; above all else you can't really share them. So each person's experience of something is completely unique, no two people can have identical experiences of the same thing.

To put it straight: The digital game itself is not the experience. The game enables the experience. So what we do, when we are talking about wrapping educational theory, we think about game design, we create artifacts (sets of rules, game boards, computer programs, . . .) that are likely to create certain kinds of experiences when human players interact with them. As a design methodology, we deploy storyboarding (Jantke and Knauf, 2005).

In figure 3, we imaged an extract of the high level graph of the designed game experience in "Catch 22".

4.4 Wrapping Educational Theory Bottom-up

The argument mapping is embedded into game play. Motivated after a conscious decision was made in a dilemma-situation, it promotes clarity and insight, more detailed and complete articulation, and more deliberate evaluation. We use argument mapping to help students to understand how arguments are constructed, and how they can enhance their reasoning skills, by bringing visual clarity to complex issues.

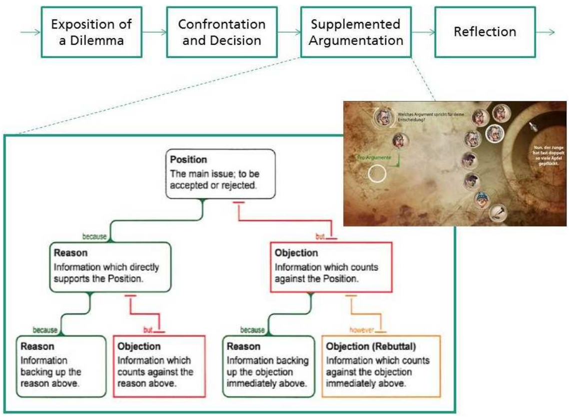

Figure 4: Expansion of an Episode by an Argument Map.

Argument mapping (van Gelder, 2013) can be an effective way to improve general critical thinking skills. Argument mapping can also promote rational reasoning in complex situations and help making better decisions in the future.

The *argument mapping technique* itself is simple but it is not easy, because it is just a visual discipline for clarifying our thinking. And clarifying our thinking is not easy, even with visual discipline.

To illustrate the issue presented, see figure 4, and notice that mapping makes it clear which statements serve as the main conclusion, which serve as reasons to believe that conclusion, and which statements are intended as objections to which claims.

5 CONCLUSIONS & OUTLOOK

Even nowadays, far too many systems of technology-enhanced learning serve mostly administrational purposes such as providing documents to learners and bookkeeping by teachers. There is a rather wide consensus that educational theory needs to be more systematically encoded into digital systems of technology-enhanced learning such as, for instance, serious games.

When storyboarding à la (Jantke and Knauf, 2005) is deployed as a design methodology, educational theory may be reflected syntactically.

For illustration, have a look at the cutout of the "Catch 22" storyboard on display in the upper part of figure 4. The linear sequence of four episodes of game play reflect the sequence of upper nodes in the visualizations of Haidt's *social intuitionist model* as shown in figure 2.

To put it straight: some pedagogy becomes visible and, therefore, the difference of varying educational theories deployed may become visually perceivable.

This opens unprecedented options of debating didactics and of experimenting with varying didactic approaches.

The *storyboard interpretation technology* makes those experiments operationally feasible, but it needs some further completion to allow for systematic routine applications as sketched in (Arnold et al., 2013) including the development of authoring tools.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the valuable support by many colleagues and friends, most notably Helmut M. Niegemann supervising the first author's Ph.D. Thesis at the University of Erfurt, Germany, as well as Jun Fujima and Sebastian Arnold being the key designers and developers of the above mentioned *Storyboard Interpretation Technology*.

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Development of an Online Research Ethics Training Resource Specific to South African Health Law and Guidance

A Ukzn-Mepi Funded Project

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Abstract: This paper describes the development of an online learning course aimed at building capacity in the field of research ethics. E-Learning is a popular tool to train large numbers of students and professionals across the world. This learning tool has been adapted to different fields and disciplines. In developing countries, there is a need to improve research ethics capacity. Generic and specific research ethics modules are being used to build capacity in Africa through various online websites. This paper describes the development of a South African online module for the Training and Resources in Research Ethics Evaluation (TRREE) website.

1 INTRODUCTION

This paper describes the development, aims and objectives of an online research ethics training module designed to familiarise researchers, members of research ethics committees and other stakeholders with applicable South African health law and research ethics guidance. This work was an integral component of a UKZN-based Medical Education Partnership Initiative (MEPI) grant from the US National Institutes of Health Fogarty International Centre to build sustainable medical education capacity in South Africa.

It is not known when e-learning emerged but e-learning has become a popular and powerful training technique both internationally and locally in South Africa. E-learning in this digital age, is a popular medium for the acquisition of knowledge and sharing of information from any area or location in the world. Globally, many tertiary institutions utilise e-learning as a common learning technique for training and capacity building in various disciplines. Online learning and distance learning are thought to be synonymous with e-learning but many see these two terms as different and separate but inter-related (Moore et al. 2011). Although not all distance education involves e-learning, e-learning is a common form of distance learning (Moore et al. 2011).

There is no consensus amongst academics about the definition and essential characteristics of e-learning, but authors (Ellis 2004) and (Nicholis 2003) suggest that e-learning can be defined as "being accessible using technological tools that are web-based, web-distributed, or web-capable. The belief that e-learning not only covers content and instructional methods delivered by CD-ROM, the Internet or an Intranet but also includes audio- and videotape, satellite broadcast and interactive TV" (Benson et al. 2002) and (Clark 2002 cited in Moore et al. 2011: 130). Despite a lack of consensus on its characteristics, e-learning can be identified as applications, programs, objects, and websites that ultimately provide a means to improve capacity and learning.

As technology evolved and improves, e-learning has become increasingly beneficial to individuals across the world and especially to those who reside in remote locations (Aggarwal et al. 2011). Distance learning, in the form of e-learning enables teaching and learning to take place in areas that are geographically distant and where infrastructure is underdeveloped (Silverman et al. 2013), either as a stand-alone resource or to supplement other capacity building formats and activities. Furthermore online learning is thought to be more attractive than traditional face-to-face training because it is available to a greater audience, is more cost effective, time-effective, scalable and sometimes an efficient tool (Aggarwal et al. 2011 and Fordis, King & Ballantyne (2005) cited in Williams et al. 2013).

E-learning is cost effective in areas where teaching and learning are under-resourced or not readily available in terms of teaching skills, experience and local facilities. In a study conducted by Aggarwal et al. 2011, Indian subjects were randomly assigned into two groups, in the first group students attended a 3.5 day onsite training on biostatistics and 3.5 week online course. In the second arm students attended a 3.5 onsite in research ethics and completed a 3.5 week online biostatistics course. The findings suggest that online training is as effective as onsite training. We further argue that e-learning might also be more sustainable as technology evolves and improves; content can be easily upgraded, edited and revised which facilitates better learning and improved knowledge.

Developers and providers of e-learning workshops from three continents met recently to discuss standards for introductory courses in human participant research ethics (Williams et al. 2013). Proceedings of this workshop highlight the importance of aims and standards of online training, and the importance of clear descriptions of these standards (Williams et al. 2013). It is argued that standards are important when developing online programmes and that they should be specifically tailored for the target audience. Williams et al. (2013) suggest that standards ensure that there is some uniformity across programmes in terms of quality of information provided to target audiences. Firstly, all important sections should be easily identified; secondly, all requirements for the programmes should be specified; lastly, an evaluation by users of the programme should be provided for. The meeting (Williams et al. 2013) identified seven standards for introductory research ethics e-learning courses. They are summarised as follows: (a) Developer/provider qualifications: Requires that authors' qualifications be provided, including a description of how the module and its contents were developed. The authors should provide a description of the educational principles used and whether the module has been peer-reviewed. (b) Learning goals: the goals of the module should meet a specified educational gap that exists in literature and the module should be designed for a specific target audience. (c) Learning objectives: Authors should provide a description of the intended usefulness of the programme. (d) Content: the content of the module should cover the basic concepts and include comprehensive background information about the topic of the module. Important and relevant concepts and principles should also be included. (e) Methods: the methods should be in line with the learning objectives. This includes details about the time needed to complete the module, background literature and articles referred to and language/s the module. (f) Assessment of participants: assessment is necessary to ensure that students have gained knowledge and understanding from the module. (g) Assessments of the course: learners taking the course should be allowed to provide feedback about the course and their learning experiences. There are several different areas to evaluate and different methods of obtaining responses. These standards ensure that all modules are the same in terms of quality and meet the needs of the target audience. A related but different set of e-learning evaluation standards is proposed and utilised by Silverman et al. (2013). It is nevertheless argued that e-learning has a growing evidence base as an effective tool for efficiently training individuals in disciplines where capacity is lacking and where disseminated training is required internationally, such as is the case in research ethics.

2 RESEARCH ETHICS CAPACITY BUILDING

There are various learning and teaching techniques available, viz. onsite and online training and it is argued that online training is a useful primary or supplementary tool for building health research capacity. Building health research capacity is a key driver to the development of efficient health systems. An important aspect of building health research capacity is ensuring that research follows ethical guidelines. Specifically, in Africa there is a documented need for research ethics capacity building (Ateudjieu et al. 2010; Kirigia et al. 2005 and Milford et al. 2006). These studies found that Research Ethics Committee (REC) members are appointed with very little or with no ethics training (Kirigia et al. 2005). Although there have been major investments in international research ethics capacity building by the US NIH Fogarty International Centre (Millum et al. 2013) and others (e.g. EDCTP and WHO/UNAIDS) in the past decade, more effective and diverse techniques of teaching and learning are needed to bridge the remaining gaps. In order to meet this need international organisations partnered with each other to develop short online courses – not all of them specifically targeting Africa. Several e-learning sites now offer training such as Training and Resources in Research Ethics Evaluation (TRREE) (see http://elearning.trree.org/),Collaborative Institutional Training Initiative (CITI) (see www.

citiprogram.org) and the National Institutes of Health (NIH) online training (see http://researchethics.od.nih.gov/) , FHI the science of improving lives (see http://www.fhi360.org/sites/all/libraries/webpages/fhi-retc2/index.html) and National Centre for Professional and Research Ethics (see https://nationalethicscenter.org/) to name a few, in addition to those described by Silverman et al. (2013). Most of these sites have generic modules provide a general overview of the requirements for the ethical conduct of health research.

3 TRAINING AND RESOURCES IN RESEARCH ETHICS EVALUATION (TRREE)

3.1 Background & Format of TRREE

In 2007 a study was conducted to investigate training needs for competent ethics review from a list of identified African and European countries (Ateudjieu 2010). The sample consisted of a total of seventy four respondents from across Africa and Europe. Participants were expected to complete a questionnaire which requested information to be given about their ethics training (Ateudjieu 2010). It was found that REC and researchers mostly received training and that majority of the participants were trained in international institutions as opposed to national institutions (Ateudjieu 2010). A list of topics was identified as important information for all researchers and REC (Ateudjieu 2010). The TRREE e-learning site was developed based on the findings from this research (Ateudjieu 2010). TRREE provides basic online training on ethics and health research regulation. It was primarily designed to provide "online and CD-ROM training modules and other resources in research ethics evaluation to a diversified audience involved in research with human participants in Africa, including research ethics committee members, researchers, students, institutional authorities, regulators and other political authorities, and any other potentially interested parties" (Ateudjieu 2010 : 90). The main objective of TRREE is to build capacity in research and ethics evaluation and to increase the existing capacity in Africa and European countries. Another major aim of TRREE is to be bilingual, to meet the needs of individuals living in Francophone countries (Ateudjieu 2010).TRREE is aimed at research ethics committee members, research teams involved in health research, health authorities, funding agencies, universities, the general public and any other health professionals who are interested in the protection in the well-being of research participants.

Of the e-learning courses described above, TRREE is unique as comprises two main sections: one section provides a growing number of country-specific modules outlining each country's specific health law and research ethics related law and guidance, in addition to a growing list of modules covering specific topics in health research ethics, such as informed consent and ethical issues in HIV prevention research.

The topic-specific e-learning modules are certificate-generating web-based learning programmes. Participants are required to read the basic and linked supplementary learning material and answer questions based on the material they have covered. Upon completion of the e-learning modules students are graded and successful participants receive a certificate if they attain over 70% correct. The national supplements are country specific e-learning modules where local experts in the field of research ethics present an overview of relevant legal and ethical guidelines that inform the practical application of research. Most TRREE national supplements are not certificate-bearing but the modules on Nigeria and South Africa includes a quiz into the module which tests students' knowledge and generates a certificate if the 70% threshold is met. TRREE learning material and resources are available in different languages based on where the module was written and who are the beneficiaries or intended audience. For example, the module written for Cameroon is available in English and French whereas the Swiss module is available in French and German. TRREE requires low bandwidth to enable participation from users in countries with poor internet accessibility, is free of charge to all users and requires the students to create an online account which is stored on the database. An active email account is needed for account confirmation and password recovery. TRREE maintains a consistent link with its users and informs them when new modules are available and when modules have been updated. TRREE also provides tools and resources such as a bibliography and a glossary. A record is kept of how many students registered and completed all modules and these statistics are used to evaluate the module and its effectiveness.

3.2 Design

All TRREE modules follow a specific template designed to standardise legal and ethical sub-headings in all the country-specific modules to facilitate ease of comparison and structured coverage. The country-specific modules also cover a standard range of subheadings which provide supplementary literature such as health law and other ethical guidelines on research for each particular setting. The module development process itself requires experts in health law and research ethics to collaborate, facilitating national and international capacity development. As all TRREE modules are available online free of charge an infinite number of users can benefit from the module. Students are required to obtain a pass mark/ grade of 70% in order to pass the module. The certificate is also acknowledged by Swiss organisations such as the FMH (Swiss Medical Association) and FPH (Swiss Association of Pharmacists). TRREE is a user-friendly learning site and the support team can be easily contacted by email if problems occur.

3.3 South African National Module

As in most countries, the ethical conduct of health research requires familiarity with and compliance with several laws and guidance documents, including the South African Health Act, the South African research ethics guidance (2004), South African Good Clinical Practice Guidelines (2006) and ethical guidelines on the conduct of HIV vaccine trials (MRC 2003). It was felt that UKZN MEPI resources would be well used if a dedicated South African TRREE module could ensure that all researchers working in South Africa, in addition to members of the over 35 registered RECs in South Africa, could have access to a module covering the essential requirements of the national laws and guiding documents in an easily accessible online format such as provided by the TRREE platform.

The first draft of the South African module was written in 2011. The module underwent several external reviews by three experts in research ethics and South African health law. In 2012, the South African authors decided to include a quiz to the national supplement which is certificate-generating and allows individuals to use the module as documenting proof of introductory-level research ethics training for the South African setting. The module and quiz was accepted in September 2013 for final programming and the module has been uploaded and is now available on the TRREE website. We are beginning to collect user statistics and user feedback. It is envisaged that this South African MEPI-sponsored TRREE module will become compulsory for all ethics applications to the UKZN Biomedical Research Ethics Committee and it is likely that other major South African health research institutions will follow suit.

4 CONCLUSIONS

E-learning is a very useful evidence-based method of preliminary or supplementary training and building capacity in the field of health research ethics. It has become especially useful in the African continent where a lack of capacity has been identified. The advantages of online training sites are that they can easily be updated and edited; they are available to an infinite number of users at relatively low cost and are readily available for asynchronous use. The lack of capacity in the field of research ethics continues to decrease as more and more training institutions commit to online learning (Silverman et al. 2013). In a digital age, international funders and training organisations can be seen utilising the internet and online mediums to train a greater number of individuals cost-effectively and we are yet to see further evolution and upgrades to online training in the field of research ethics and other disciplines.

ACKNOWLEDGEMENTS

We would like to acknowledge the following people: The MEPI PI, Prof Umesh Lalloo, members of the MEPI management team, Dr Sandy Pillay, Dr Nisha-Nadesan Reddy.

We would like to also thank the TRREE team, Prof Dominique Sprumont, Dr Joanna Bourke-Martignoni.

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Defining and Exemplifying Semantic Widgets for Learning

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Keywords: Semantic Widgets, Semantic Technologies, Web of Data, Web 3.0, Metadata, Schema.org, Visual Learning, Infographics.

Abstract: In this article, we make the case for widgets as an appropriate vehicle for interacting with the Web of Data in learning applications and materials. In the article, an attempt is made to define and exemplify the concept of semantic widgets for learning (SW4L) and to suggest how such educational software may be exposed and utilized in the Web of Data. As an example of SW4L, we mention widgets operating on semantic learning content marked up using the web vocabulary of schema.org and illustrate how they may be designed to support instructional guidelines advocating the use of visual aids in learning materials.

1 INTRODUCTION

As the Web is moving from a Web of Documents to a Web of Data (aka The Semantic Web or Web 3.0), and to a Web of Things, educationalists are beginning to discuss how semantic technologies may be put to use in educational settings and, more narrowly, how learning applications can make use of semantically represented data to enhance learning experiences, (see for instance Carbonaro, 2012).

Ideally, the Web of Data has a great potential for learning, teaching and education. It brings with it the promise of improved discoverability of learning resources, greater reuse of learning content, increased adaptation and personalization of learning materials, more reliable data analytics of user performances, preferences and behaviors, enhanced opportunities for collaboration via social media and so forth.

Palmér (2012) presents some recommendations for building learning applications based on Semantic Web technology and discusses some of the main obstacles found in the process. Other studies explore different combinations of Semantic Web, Web widgets and learning (see Mäkelä et al., 2007 and Soylu et al., 2010). However, it is not altogether obvious how we should go about creating multi-platform "semantic solutions" that can be used to support real learning activities in authentic educational contexts by ordinary teachers and professors. What kinds of applications, or components, are needed and how can these naturally be integrated into existing learning architectures, media and materials?

In this article, we make the case for embedded reusable components as an appropriate vehicle for interacting with semantic content in learning applications and materials. More specifically, we suggest how *semantic widgets for learning* may be designed and exposed on the Web of Data as shareable educational resources.

In section two, we attempt to define and delimit the concept of semantic widgets for learning. Semantic widgets for learning are described and categorized on the basis of their characteristics as reusable software modules, their functional roles as learning support tools, their capability to operate on structured semantic learning content and, finally, their discoverability on the Web of Data.

In section three, we exemplify the concept of semantic widgets for learning. We do so by introducing one kind of semantic widgets, namely widgets operating on content or data marked up using the widely used web vocabulary of schema.org. We illustrate how such widgets may be designed and developed to support instructional guidelines advocating the use of visual aids in learning materials.

In section four, we suggest how semantic widgets for learning themselves may be annotated to enhance their discoverability and reuse on the Web of Data. Once again, we recommend deploying schema.org categories.

In section five, the conclusions, we briefly argue why we think that the approach proposed here is worth pursuing and what implications such an approach may have for the adoption of semantic functionality in learning applications and materials.

2 SEMANTIC WIDGETS FOR LEARNING - WHAT?

According to Cáceres (2012), a widget is an interactive single purpose application for displaying and/or updating local data or data on the Web, packaged in a way as to allow a single download and installation on a user's computer or mobile device. Alternatively, a widget may be embedded in a web page to provide additional functionality. These days, widgets are often created using HTML5, CSS and JavaScript to ensure that they can run on different platforms and in a wide range of browsers and other user agents.

Because of their potential for reuse and wide applicability, widgets are becoming popular in educational media, applications and materials, too. One example is iBooks, Apple's format for e-textbooks on the iPad. Employing the authoring tool, iBooks Author, e-book writers can embed widgets in their electronic text to provide more engaging learning experiences for their users. These widgets may realize interactive multi-modal curricular content objects, communication tools, exercises, etc. To create a widget, an iBook author may utilize iBooks Author's own built-in widget template, develop his or her own from scratch in HTML5 (possibly using an authoring tool) or configure and download a widget from Bookry.com, one of several websites offering templates for the construction of widgets for iBooks.

Thus, a widget for learning may be defined as an embeddable software module designed to support one or a small number of learning activities. A widget for learning might:

- convey subject matter
- facilitate comprehension of subject matter
- help learners search, retrieve, explore and organize content
- enable learners to communicate, share knowledge or create signs of learning
- facilitate simulation or skills practice
- analyse a relevant data set
- test or evaluate specific learning outcomes
- compensate learners' disabilities

Widgets for learning may further be divided into subclasses depending on the learning theory they support or the instructional design principle(s) they seek to instantiate. For example, a widget manipulating visual learning content to facilitate the comprehension of subject matter may, explicitly or implicitly, be designed to implement one or more of Mayer's principles of multimedia learning, (Mayer, 2009) or Carney and Levin's "10 tenets for teachers", (Carney and Levin, 2002).

Conceptually, widgets for learning are similar to learning objects. One popular definition of learning object is this one:

A Learning Object is an independent and self-standing unit of learning content that is predisposed to reuse in multiple instructional contexts, (Polsani, 2003).

Both learning objects and widgets for learning are, in other words, digital educational resources created with reuse in mind. Although the boundary between the two notions is somewhat fluid, it may be argued that widgets for learning primarily provide interactive functionality to support learning activities and processes while the main role of learning objects normally is to convey subject matter.

A semantic widget for learning (SW4L) may generally be defined as a widget for learning designed to extract, display or manipulate "semantically structured data" typically, but not invariably, exposed on the Web of Data. Characteristically, these data:

- contain global identifiers to denote entities, and types of entities, on the Web,
- utilize syntaxes like RDF/XML, Microdata, RDFa (Lite) or JSON-LD,
- point to descriptive categories belonging to publicly available vocabularies on the Web such as schema.org, SKOS, FOAF, or ALOCOM,
- contain typed links to connect entities across data sets.

3 SEMANTIC WIDGETS FOR LEARNING - ONE EXAMPLE

To exemplify the concept of SW4L, one may mention semantic widgets designed to function on digital resources marked up using the web vocabulary of schema.org (http://schema.org). This is a set of descriptive categories, properties and relations devised and supported by the three major search engines, including Google's. Schema.org offers a wide range of options for semantically enriching digital resources (for learning): Firstly, it may be deployed to add traditional metadata to resources, in schema.org parlance "Creative Works", be they textual, visual or audial (books, articles, images, videos, sound bites, etc.). Secondly, it provides some means for encoding information about the subject matter of these resources in the form of types, properties and actions (X is a kind of Y; X has property Z; X does A to B at place C). Thirdly, it supports Linked Data mechanisms to create pointers into external learning object metadata schemes such as ALOCOM or web-based data sets like Freebase or DBpedia. Last but not least, the schema.org vocabulary is compatible with several markup syntaxes, currently Microdata, RDFa (Lite) and JSON-LD. This means that schema.org metadata can be applied to many forms of digital content: it can be embedded in online web pages as well as off-line e-books since the most recent version of the EPUB format (3.01) supports Microdata and RDFa (Lite); it can be encoded in running text or embedded in two-dimensional graphics provided that the format is SVG.

To illustrate how SW4L's based on schema.org metadata may work to achieve instructional design goals, we are developing some reusable widgets in HTML5/CSS/JavaScript within a use case context. These widgets are meant to provide learners access to infographics, multi-modally presented content, about the topic they are studying.

The use of infographics, especially advance and graphical organizers (see below), in instructional materials has been extensively discussed in the literature and their usefulness as learning support tools empirically tested and evaluated, (see for instance Ausubel, 1978, Carney and Levin, 2002 and Mayer, 2009).

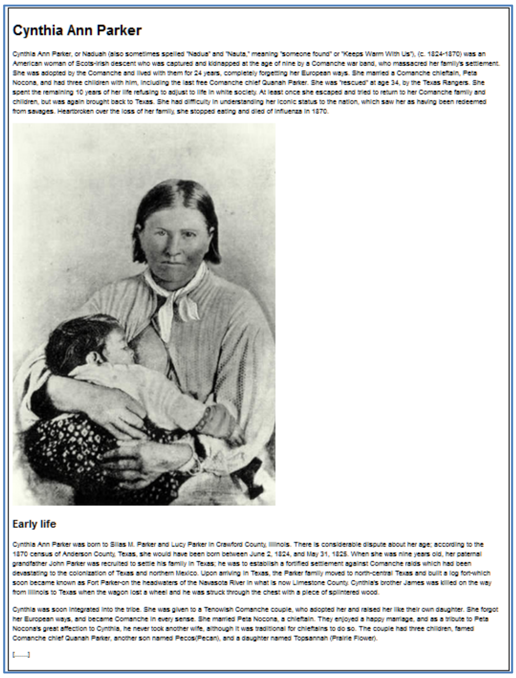
On the surface, a semantic widget for learning (based on schema.org input) may look like a traditional piece of educational software. The difference is, however, that such widgets are supposed to provide more *standardized, and therefore more reusable, metadata-driven designs*. A semantic widget generating, say, a visual timeline on the basis of data distilled from a web page marked up using the schema.org category of "http://schema.org/Event" will do the same to any text containing data of this type.

3.1 Use Case - Generating Graphic Organizers

One use case involving the use of infographics in learning designs is centred round graphic organizers, visual reading adjuncts designed to promote identification, comprehension, recall and retention of conceptual or narrative structure in running text, (see Stull and Mayer, 2007). Graphic organizers comprise synoptic visuals such as tree structures, matrices, charts, diagrams, concept maps and flow charts usually placed in close proximity to the text they are to represent.

Normally, such aids are "hardwired" into the material as embedded static resources. More dynamic, engaging and customized graphic organizers can be envisaged, however, if widgets are allowed to operate on semantic data structures consistently marked up inside, or linked to, the text itself. Metaphorically, these data structures may be conceived of as a kind of latent "semiotic enzymes". They lie dormant in the learning material ready to trigger text transformation processes of various types, for example visualization. And if the text contains typed links to external data sets, subsets of these data may be extracted and added to the visualization output to enhance or elaborate its communicative purpose.

Visualizations like graphic organizers may be interactively controlled: A learner may choose to see the text's key concepts as a network diagram beside the text or as a transparent overlay with lines connecting the individual concepts in the text. He or she may be able to control a slider permitting him/her to incrementally "gray out" less important parts of the text; or he/she may be able to fold the



Cynthia Ann Parker

Cynthia Ann Parker, or Naduah (also sometimes spelled "Nadua" and "Nauta," meaning "someone found" or "Keeps Warm With Us"), (c. 1824-1870) was an American woman of Scots-Irish descent who was captured and kidnapped at the age of nine by a Comanche war band, who massacred her family's settlement. She was adopted by the Comanche and lived with them for 24 years, completely forgetting her European ways. She married a Comanche chieftain, Peta Nocona, and had three children with him, including the last free Comanche chief Quanah Parker. She was "rescued" at age 34, by the Texas Rangers. She spent the remaining 10 years of her life refusing to adjust to life in white society. At least once she escaped and tried to return to her Comanche family and children, but was again brought back to Texas. She had difficulty in understanding her iconic status to the nation, which saw her as having been redeemed from savages. Heartbroken over the loss of her family, she stopped eating and died of influenza in 1870.

Early life

Cynthia Ann Parker was born to Silas M. Parker and Lucy Parker in Crawford County, Illinois. There is considerable dispute about her age; according to the 1870 census of Anderson County, Texas, she would have been born between June 2, 1824, and May 31, 1825. When she was nine years old, her paternal grandfather John Parker was recruited to settle his family in Texas; he was to establish a fortified settlement against Comanche raids which had been devastating to the colonization of Texas and northern Mexico. Upon arriving in Texas, the Parker family moved to north-central Texas and built a log fort-which soon became known as Fort Parker-on the headwaters of the Navasota River in what is now Limestone County. Cynthia's brother James was killed on the way from Illinois to Texas when the wagon lost a wheel and he was struck through the chest with a piece of splintered wood.

Cynthia was soon integrated into the tribe. She was given to a Tenowish Comanche couple, who adopted her and raised her like their own daughter. She forgot her European ways, and became Comanche in every sense. She married Peta Nocona, a chieftain. They enjoyed a happy marriage, and as a tribute to Peta Nocona's great affection to Cynthia, he never took another wife, although it was traditional for chieftains to do so. The couple had three children, famed Comanche chief Quanah Parker, another son named Pecos(Pecan), and a daughter named Topsannah (Prairie Flower).

[......]

Figure 1: Example of text being reviewed by a learner: a snippet of "Cynthia Ann Parker’s" biography from Wikipedia.

text in and out to display chronological sequences of events or actions in the underlying narrative structure.

Such options can obviously aid learners of different learning styles but also more generally provide multimodal means of foregrounding or re-iterating central meanings in the domain being described, typically concepts, facts, procedures or rules. Semiotically speaking, the semantic widgets perform *transduction*, i.e. remake or reshape meaning in different semiotic modes: text, color, typography, spatial position, etc., (see Bezemer and Kress, 2008). In so doing, they will bring to the fore certain semantic aspects of the text while subduing others.

Figure 2: Graphic organizer of the text in Figure Figure 1. Here the marked up text of persons and their relations is highlighted while the rest of the text is grayed out.

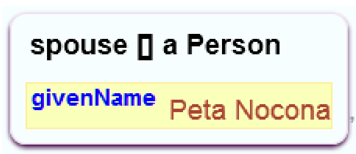


Figure 3: Detail from the highlighted text in Figure 2.

As more and more visual design tools, script libraries and programming environments see the light of day, more, and increasingly sophisticated, infographics for learning may be developed - and with less effort. To emphasize this point, we have created the graphic organizers shown in the figures in this paper with publicly available tools:

- The styling shown in Figure 2 has been made using rdfa-lab (Niklas Lindström (c) 2012). (https://github.com/niklasl/rdfa-lab)
- The node graph in Figure 4 has been built using D3.js javascript library, based on Mike Bostock's Collapsible Tree. (http://bl.ocks.org/mbostock/4339083)

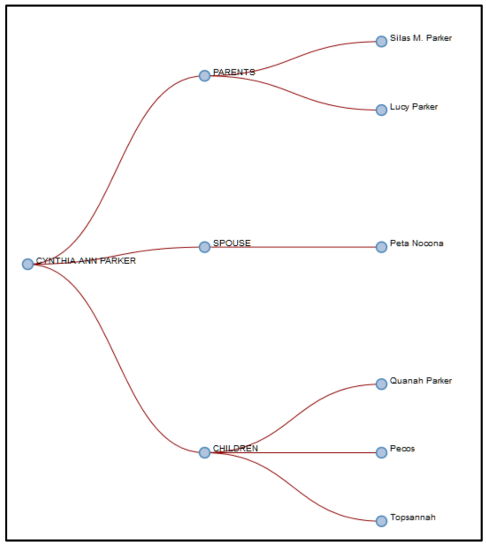


Figure 4: This graphic organizer is representing personal relations in the text in Figure 1 as a graph.

4 SEMANTIC WIDGETS FOR LEARNING - HOW TO ANNOTATE AND EXPOSE THEM?

Needless to say, semantic widgets for learning are pretty useless as reusable resources if they cannot be efficiently discovered and retrieved from the Web and effectively evaluated as educational software by potential users. This in turn will only be possible if the widgets contain relevant metadata about themselves as educational resources and if these metadata are represented in formats that can be consumed by search engines and similar software tools. Semantic widgets should take their own medicine, as it were!

We propose that three types of metadata be attached to semantic widgets for learning:

Firstly, they should be described in terms of their characteristics as software applications (e.g. application category, file format, system or device requirements, version number, feature list, installation details, etc.). Secondly, information about their function as learning resources should be provided (e.g. instructional goal, intended audience, subject, topic, learning scenario or educational setting, underlying instructional theory, etc.). Thirdly, it should be made explicit what data sets they operate, or are expected to operate, on (e.g. URL, format, descriptive vocabulary, etc.)

To endow semantic widgets for learning with technical, pedagogical/didactical and "data target" metadata, we recommend once more employing the schema.org vocabulary. There are several reasons for this:

- Schema.org is supported by the three major search engines. This is likely to mean enhanced discoverability and improved presentation of search results in the (near) future but no doubt also the availability of more and better tools for tagging and annotation.
- Schema.org contains descriptive categories and properties to annotate all three types of metadata recommended above: To describe semantic widgets as software, the category of SoftwareApplication and its properties may be applied. To indicate what data is at play, the categories of Dataset, DataCatalog and DataDownload are available. And, finally, to designate instructional characteristics, selected properties of the CreativeWork type (e.g. Article or Book) come in handy. Originally, schema.org did not offer labels to tag educational (web) content. But recently schema.org has adopted a set of categories from The Learning Resource Metadata Initiative, LRMI, (http://www.lrmi.net) allowing publishers and others to annotate educational resources and, equally importantly, to align these resources with existing external educational frameworks and standards (e.g. LOM and Common Core State Standards).
- Schema.org can then function as a "one-stop shop" for publishers of semantic widgets for learning who only need to go to one place when looking for appropriate categories for description and annotation.
- Schema.org types and properties are, as already said, compatible with all major data formats associated with Linked Data and Web 3.0 (Microdata, RDFa Lite, JSON-LD).

5 CONCLUSIONS

Now, what are the potential benefits of semantic widgets for learning? We think there may be a few:

As mentioned, semantic widgets necessarily entail a more standardized, and therefore more reusable, way of operating on data.

Semantic widgets may be embedded in a wide range of learning applications and materials, including e-textbooks, web pages and so on. That is to say, we can incorporate, or "plug in", limited semantic functionality in otherwise traditional educational resources. This, we think, will significantly lower the barrier to the Web of Data in authentic learning contexts and settings.

Since semantic widgets for learning are small(ish) and modular in terms of functionality, and hence code, they can be produced fairly easily and cheaply and in a piecemeal fashion. And if semantic widgets for learning are produced and distributed under Creative Commons and/or Open Source licenses, there is no reason why, in due course, we should not see a thriving "home industry" in this area. For example, one may envisage web sites similar to Bookry.com specializing in semantic widgets for specific publication channels like interactive e-textbooks based on EPUB 3.01.

Semantic widgets may be linked to specific data sets to form "live" learning objects, that is to say interactive, multimodal dynamic learning units drawing on different resources on the Web of Data. Again, this can be done using the schema.org vocabulary, which contains categories for describing and linking to downloadable data sets anywhere on the Web.

Last, but not least semantic widgets for learning have generally the potential to support what has elsewhere been dubbed "Learning Content Design as a Service" (see Johnsen & Hansen, 2013). The fundamental idea is that consistently structured, i.e. semantically encoded, content for learning can be freely linked to semantic widgets on the web creating richer and more engaging educational resources.

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Towards a New Generation of Learning Management Systems

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Keywords: LMS, Learning Network, Distance Education, Liferay, Portal.

Abstract: In this paper we argue that a centrally governed Learning Management System (LMS) still has ample legitimacy in an information society that is ever more adopting cloud computing services in daily life. We argued that control over services and produced data is essential from the perspective of an educational institute for reasons of accountability, quality control, legislation, privacy and reliability. However, the current generation learning management systems are primarily geared to provide 'additional' online learning. In 'real' online learning teachers and students almost never need to meet face-to-face. All instruction, tests, communication and collaboration is organised using internet and mobile technologies. We propose a paradigm shift for the next generation LMS, discarding the course as key concept in favour of the social learning network concept. We argue that a generic social collaborative portal platform is a good foundation for the development of this next generation LMS. We support our arguments by presenting a real world case and we conclude that we can reuse 80% of the standard code.

1 INTRODUCTION

So, what to do when you are seriously planning to provide 'real' online learning for students you will never meet or see? Are the traditional LMSs that are currently locally implemented as an add-on to campus-based education usable for these purposes or is it better to implement and use another solution?

The uptake of 'real' online learning has grown massively in the past years driven by the public attention and uptake of Massive Online Open Courses (MOOCs). The term 'real' in the previous sentence is contrasted to the term 'additional' online learning, i.e. additional to campus-based teaching and learning. In real online learning teachers and students almost never need to meet face-to-face. All instruction, tests, communication and collaboration is organised using internet and mobile technologies. In the last decade many universities and schools have implemented a dedicated Learning Management System (LMS) such as Blackboard or Moodle to be used in addition to the regular campus-based teaching and learning. Its use is mostly restricted to the sharing of PowerPoint slides, information about grades, examinations, classroom changes, providing access to online books, papers and other resources. The real work and instruction is mostly done outside the LMS. Given that the main users of LMSs are using the LMS as an addition, it is likely that the requirements for the development of these platforms are mostly driven by this extended classroom paradigm and not by requirements stemming from 'real' online learning. In practice most universities that are using MOOCs use different (or adapted) platforms, like Udacity, Coursera or Futurelearn.

Using these MOOC platforms may be satisfactory from the learner's perspective; it is not necessary desirable from the educational institution's perspective, for whom the online platform is an essential, integral part of the core business. Such educational organisation is obliged to offer these services at an agreed level of quality and availability. Furthermore, educational institutions want to have access to all learning performance data so the learning and teaching can be improved by applying learning analytics technologies. Also legislation, internal quality control and privacy issues imply that an educational institute is responsible and accountable for these data. An educational institution simply cannot take accountability for services in the cloud that are not under their control. Hence, an integrated, centrally governed infrastructure for online learning has still got its legitimacy. However, such an infrastructure requires a paradigm shift from a limited view on online course support towards a more inclusive view on ‘real’ online learning. This raises a question: what is the best technical foundation for implementing such paradigm shift. This question will be addressed in the next sections by discussing an implementation of such an infrastructure at the Open University of the Netherlands.

2 THE LMS BEYOND THE COURSE

In 1984 the Open University of the Netherlands (OUN) was established as an institute for open higher distance education for adult learners. Its major goals were (1) to offer adult learners a second chance to higher education and (2) to provide an alternative route to higher education in order to reduce the load on costly traditional, face to face education. The Open University started in 2010 with the development of the infrastructure for their next generation LMS, which is called OpenU.

Hermans, Kalz, & Koper (Hermans et al., 2013) distinct three types of online environments in which adult learners act:

- The LMS, built around the course concept and intended for formal instruction;
- The Personal Learning Environment (PLE), governed by the learner;
- Social network sites and learning networks (LN) for social and informal learning.

OpenU has the ambition to support all three online environments through the same infrastructure. Therefore, OpenU should be able to support various target groups in their formal and informal learning needs in a distance education setting. These target groups include master, bachelor and PhD students, but also professionals wanting to keep up with latest developments and trends in their area of expertise. But also researchers should be enabled to showcase and discuss the state of art in their topic of research, i.e. to increase the impact of their research. OpenU should allow learning networks to be established for all target audiences, but it should also be possible to cross these boundaries and bring students, professionals and researchers into contact with each other. Informed by a social constructivism view on learning, emphasizing that the development of knowledge and skills require intensive social interactions (Schunk, 2012) OpenU should provide ample social tools. Finally users should be allowed to construct their own personal learning environment and the self-directed learner should be encouraged to explore formal and informal learning opportunities. Therefore a substantial part, about 10%, of all learning materials will be offered as Open Educational Resource (OER). Students and professionals should be able to receive credits for their participations in these MOOCs, which can be used in either their curriculum or for their professional development. From these use cases we derived a set of high level requirements for OpenU.

Social and Collaborative Requirements

- The system should allow grouping and participation of users into communities. Each community should have a virtual presence on the web;
- It should be possible to set fine grained access rights to these communities, based on the role of a user in such a community;
- A user should be able to define an online identity;
- Various social tools should provide the social cohesion in the system and should allow and promote collaboration.

Content Management/Publishing Requirements

- Users should be able to collaboratively create and manage digital content. This content can take various formats, such as web pages, Wiki pages, blogs and files;
- It should be possible to set detailed access rights to this content, controlling who can create, edit, delete and view the content;
- It should be possible to create web pages for the created content including possibilities to control layout and navigation.

Portal Requirements

- Users should have a single access point for their learning. The system should provide an integrated and consistent user experience.
- It should be possible to combine functionality in a flexible manner to construct the different types of learning networks as each type of learning network has slightly different requirements.
- The system should be open allowing the seamless integration of various external services.

LMS Requirements

- Learners should be able to keep track of their study progress while performing the activities of a learning design.
- It should be possible to upload, discuss and review assignments.

- The system must support the creation and delivery of self-assessments. It should be possible to incorporate these self-assessments into a course design.
- It should be possible to monitor study progress by learners and tutors alike, including self-assessment outcomes.
- Users should have their own portfolio and it should be possible to create showcases based of the data in the portfolio and traces of their activities within the system.
- It should be possible to implement various pedagogical approaches and course designs for the different target audiences.

3 THE LIFERAY PORTAL

When reviewing the global requirements one can argue that there are several types of systems that provide a good foundation to achieve the desired functionality. Content Management Systems (CMS), Social Networking Systems (SNS), Web Publishing Systems, Portals and traditional LMSs all provide parts of the required functionality. However, no single of these systems will meet all requirements.

Given that no system meets all of our requirements, the following question arises; what is the best foundation for developing the next generation LMS assuming that it makes no sense to start from scratch? One obvious strategy would be starting with a traditional LMS, such as Moodle or Blackboard, as starting point. However, the focus on the extended classroom and course paradigm probably would hinder a swift integration of social and informal learning objectives in OpenU. An alternative strategy would be using a more generic system that is free from any pedagogical paradigms. We argue that the latter approach is the better, more flexible approach towards the next generation LMS. In the next section we will discuss the OpenU case and show how we have configured and extended the Liferay portal environment (Liferay Portal, 2013) to meet our requirements.

Liferay provides a major part of the required functionality by integrating several relevant subsystems into a single framework. Some characteristics of Liferay are:

- Liferay is a full JSR-286 (Hepper, 2005) portal. It will allow the creation of a singular user experience through portlet technology.
- Liferay has an integrated CMS, complete with workflow control. It supports various content types.
- Liferay provides a social, collaborative environment via a range of social portlets.
- Liferay is based on an extendable open service architecture that allows bidirectional exchange of data through well-defined and standardized interfaces such as web service and JSON/REST.

However, Liferay is lacking specific LMS functionality which therefore needs to be added. In the next three sections we will describe how we used and configured Liferay to meet our requirements and we will describe what components we added.

3.1 Setup of Liferay as LMS

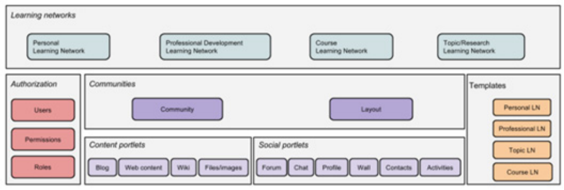

Figure 1: Basic Liferay functionality.

Figure 1 depicts a high level, layered functional decomposition of the OpenU LMS, based on an out of the box Liferay portal. We will explain how we decided to map the main Liferay concepts to build our learning networks. The top level represents the four learning network types that OpenU currently supports:

- The Personal Learning Network is owned and largely controlled by the user. In effect this is the OpenU implementation for a PLE. All users have their own personal learning network which they control;
- The Course Learning Network is intended for delivery of formal, designed courses for the bachelor and master curricula. Most members will be course students, but prospective students and professionals are allowed to participate as well, although they will not receive support by any Open University staff.
- The Professional Development Network focuses on latest trends and developments that are especially of interest to professionals desiring to keep up with latest developments in their profession. Although these networks are intended to address continuing professional development, regular university students can participate in them as well. Both professional and students can receive credits for their participation.
- Topic/research networks focus on the state of the art on main research topics. The intended audiences are researchers, students and

professionals alike.

A learning network is implemented via the Liferay 'community' concept. A Liferay community consists of a number of web pages and each of these web pages can contain portlets in a specific layout. A portlet occupies a part of the screen estate and its functionality can range from something very simple such as displaying a piece of web content, to a full fletched interactive group wall application. One can compare these portlets with Lego bricks. Each type of Lego brick provides a basic building block, but only the combination certain bricks result in a desired model. Similar, only after combining a particular set of portlets this will result in the desired learning network type.

Besides determining which portlets should be combined on a page, we also must define who is member of a learning network and what rights each user should have within the network. In Liferay this authorization is handled through a role based permission system. A standard role, for example, is the community member role. But it is possible to define as many roles as required. The actual permissions that can be set vary per portlet. Typical permissions are view and edit permissions.

With these standard Liferay concepts it is possible to construct a basic learning. However, configuring each learning network from scratch would be impractically at best. Liferay provides a template mechanism for automating this process. We defined a template for each type of learning network.

The bottom layer of Figure 1 is formed by the Liferay portlets, the equivalents of the Lego bricks. This includes content management portlets as well as social and collaborative portlets. With this approach and the standard portlets it is only possible to create very basic learning networks. Advanced learning networks will require additional LMS functionality that is not available out of the box.

3.2 Extending Liferay

Liferay provides an open API and SDK for developing new portlets which can be either build from scratch or can reuse services from existing portlets. We extended Liferay with a number of educational portlets that are required to turn Liferay into a LMS using both aforementioned portlet development strategies.

Figure 2 depicts the new high level functional architecture of Liferay including these extensions.

The following additional portlets have been developed:

- *Assignment portlet*: this portlet allows the sharing and discussion/rating of assignments with tutors;
- *Assessment portlet*: this portlet allows the creation of assessments and provisions these assessments to learners;
- *Sequencing portlet*: this portlet builds on the Liferay Wiki and allows the construction of learning designs that are very similar to IMS-LD level A. The course author can create and sequence learning activities. On a role basis, the course author can determine who should perform which learning activities;
- *Showcase portlet*: allows users to share evidence of their learning progress via a showcase. The showcase portlet was initially developed as part of the EU lifelong learning programme project TRAILER (Brouns, Vogten, Janssen, & Finders, 2013);
- *Monitor portlet*: portlet that provides tutors with information about the progress of students in the learning network;
- *Groupwall portlet*: a portlet build on top of the Liferay forum resembling the Facebook wall feature, but owned by the network community.

With these additional portlets in place, we were capable of implementing all four learning network types. However, populating these networks with actual users is very labor intensive and therefore also error prone, especially when the number of users increases. Additional software is required to manage these subscriptions.

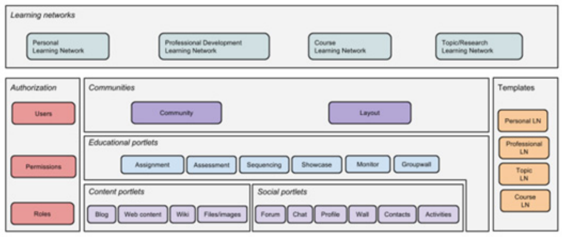

Figure 2: Extended Liferay functionality.

3.3 Subscription Management

Figure 3 depicts the functional architecture with an additional subscription management layer. Informed by the 'separation of concerns' design principle, this management layer hides all specific Liferay configuration details.

This is achieved through the introduction of a semantic neutral artefact called 'product'.

The UML class diagram of Figure 4 represents this product artefact and its relationship with the Liferay concepts. The standard Liferay artefacts all have a grey background color. A product represents

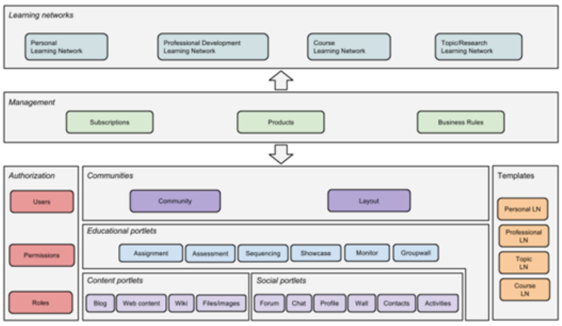

Figure 3: Subscription management layer.

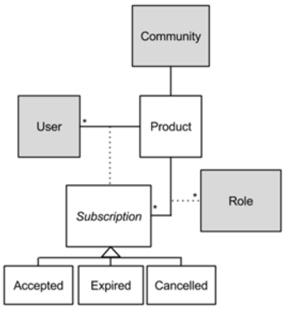

Figure 4: UML class diagram for product artefact.

a learning network via its association with a community. A product also defines which Liferay roles are associated with a subscription instances. A subscription instance has a state of either *accepted*, *expired* or *cancelled*. A user can have a subscription for a product, which is therefore either accepted, expired or cancelled.

Setting or changing a subscription will trigger a recalculation of the associated Liferay role assignments for the subscription user. This guarantees that a user always has the correct Liferay permissions in accordance with the product subscriptions. A product subscription can be set from various sources. For example, in the case of OpenU, a proprietary student administration system acts as source for all subscriptions of the bachelor and master students. Product subscriptions can also be set as a result of a purchase in web shop or simply via as a result of an open registration. The latter is typically when accessing the open educational resources. Regardless what the source of the subscription is, all role assignments will be automatically calculated without any further need for manual intervention and as a consequence the correct Liferay permissions are granted to the user.

Finally, we have implemented some registration business rules that allow the definition of products dependencies. With these business rules it is possible to define flanking products for a source product, meaning that a user will be automatically subscribed to these flanking products whenever a user is subscribed for the source product.

4 IMPLEMENTATION

To get an impression about the efforts required to extend Liferay we performed some code metrics analysis. We have used the CLOC 1.6.0 (CLOC, 2014) for this purpose. Table 1 represents the result of running the code metrics on the sources of the standard Liferay 6.0.12 EE product.

Table 1: CLOC statistics for standard Liferay Portal.

Language	files	code
Java	17581	1881276
HTML	4190	409408
JSP	873	68249
XML	227	44102
CSS	39	5809
Javascript	117	34715
XSD	21	18250
SQL	32	5821
XSLT	5	169
SUM	**23085**	**2467799**

Table 2 has the code metrics for the extensions of the Liferay code that we have developed. This includes the educational portlets as well as the code for subscription management layer as described in the previous sections. It also includes some very specific code for the integration with the Open University infrastructure, such as the identity management services. However, these specific additions have only a minor impact on the statistics because they are relative small in size.

Although we didn't use all available functionality of the standard Liferay Portal, we used a very large portion of it. Therefore we may conclude that roughly 80% of the code needed to implement OpenU was realized with standard Liferay code and roughly 20% had to be developed from scratch.

The source code of all extensions is available as Open Source through SourceForge at http://sourceforge.net/projects/openu/

Table 2: CLOC statistics for the Liferay Portal extensions.

Language	files	code
Java	2291	374844
HTML	7	423
JSP	150	10298
JSF	295	24841
XML	306	18739
CSS	69	15541
Javascript	31	4909
XSD	1	230
SQL	23	1016
XSLT	1	77
SUM	**3174**	**450918**

5 CONCLUSION AND DISCUSSION

So, what have we learned? Most LMSs have dedicated code for teaching and learning, but this is built on a more generic functionality layer that can also be found in most portal and CMS software platforms. In our situation we found that only 20% of the code is specific to an LMS. Furthermore, the educational model of a distance teaching university like the OUN requires a specific set of teaching and learning modules that are hard to find in a standard LMS. At the pedagogical level there are many choices to make. For instance whether or not to implement informal and social learning as described in this paper. Many users of traditional LMSs need to adapt and configure the platform substantively in order to fit the specific local educational requirements or when delivering 'real' online education at substantive scale. In this effort they could be hindered by underlying restrictions in the models applied by the developers of the LMS. For instance, most LMSs embrace the course and extended classroom concepts in their core, which can be difficult to change towards more generic concept like learning networks.

The real issue in selecting and implementing an infrastructure for teaching and learning is to find a suitable platform that fits into (and connects to) the existing infrastructure, is secure, flexible, stable and scalable, provides generic CMS, communication and collaboration tools out of the box and is extensible and adaptable. But of course, this is in our opinion the best way to proceed when one is serious in implementing 'real' online learning.

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Nanoscale Education for Semiconductor Design

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Keywords: Nanotechnology, Learning Processes, Learning Objects, Curriculum Design, Nanofabrication, Bottom-up, Top-down.

Abstract: Over the last decades, nanotechnology had established itself as the upcoming revolution in science and technology. The ability of manipulating material at the atomic and molecular levels allowed nanotechnology to open an entirely new paradigm of devices and products. In the semiconductor industry several new nanodevices have been proposed to replace the classical CMOS devices that have been used over the last four decades. These new nanodevices have shown significant potential to overcome the fundamental limits of current CMOS devices. However, limited educational resources and processes are available to prepare future nanotechnology engineers and scientists to integrate these promising nanodevices into the main semiconductor manufacturing streams. This paper proposes new learning structures and processes to propagate nanotechnology learning resources over the pervasive Web. The proposed approach is illustrated by a case study centered around the manufacturing of future nanodevices. We adopt standard structures and processes to organize and navigate through digital instructional contents, such as IEEE LOM and IMS LD. In doing so, we aim at streamlining the propagation of reusable repositories across the open Web to facilitate the integration of nanotechnology learning resources into the rising social trend of massively open online courses (or MOOCs).

1 INTRODUCTION

Nanotechnology was formally defined in the 1999 NSF workshop report as "the ability to control and restructure the matter at the atomic and molecular levels in the range of approximately 1–100 nm, and exploiting the distinct properties and phenomena at that scale as compared to those associated with single atoms or molecules or bulk behavior. The aim is to create materials, devices, and systems with fundamentally new properties and functions by engineering their small structure" (Roco et al., 2000). In 2001 Uddin and Chowdhury (Uddin and Chowdhury, 2001) stated that the fundamental objective of nanotechnology is to model, simulate, design and manufacture nanostructures and nanodevices with extraordinary properties and assemble them economically into a working system with revolutionary functional capabilities.

Applications in a wide spectrum of areas ranging from nanomaterials to industry-specific applications in biotechnology, electronics and energy, are creating unique opportunities all over the World. With the latest advancement in nanolithography and optical proximity correction, the semiconductor industry was successfully able to scale the transistor size further to 20nm. This deep scaling into the nanometer range has enabled several new mobile and communication applications including wearable computers, intelligent handheld devices, healthcare implantable devices , and self-powered wireless sensor networks to mention a few. Today, there are more than 1,300 consumer products containing nanotechnology components, while the inventory of products has grown by over 500% in the last five years (Rodgers et al., 2013). Trends suggest that by 2020 there will be a 3 trillion dollar market with 6 million employees in this field (Roco, 2011).

In order to sustain this successful trend, it is essential to have sufficient workforce with an intensive and focused training in nanotechnology. Unfortunately, because of the interdisciplinary nature of the nanotechnology field (Porter and Youtie, 2009), this kind of workforce is hard to develop. A skilled nanotechnology specialist should have good understanding of several other science and engineering fields including math, material and biomedical sciences, chemistry, physics, computer and environmental sciences, among others. Currently, due to the lack of a proper nanotechnology education, nanotechnology nspecialists develop the required knowledge through training courses and on the job learning experience.

Nanotechnology is rapidly growing as a separate discipline by itself (McNally, 2013). However, one major challenge asscoiated with the growth of this discipline is the substantial cost required to provide laboratory experiences. These hands-on practices are essential to experience nanoscale matter (atoms and molecules), and to design nanodevices and systems. The associated cost can be reduced significantly by relying on reusable electronic simulations and Web-based repository of concept resources.

Another typical aspect in nanotechnology education, which is not well supported in existing digital instructional approaches, is the “zoom” effect, which hierarchically and gradually reveals the infinitesimal structures of nanomaterial. An alternative “assembly” effect could empower existing digital instruction to get learners exposed to both bottom-up and top-down approaches of nanostructures manufacturing. In this paper, we propose to augment existing learning technology standards for supporting the design and the development of virtual learning environments.

We adopt standard structures to organize digital instructional contents and processes, such as IEEE LOM (Atif et al., 2003) and IMS SCORM (Hsu et al., 2010). In doing so, we aim at streamlining the propagation of reusable repositories across the open Web to facilitate the integration of nanotechnology learning resources into the rising social trend of Massively Open Online Courses (or MOOCs) (Zhang, 2013).

2 BACKGROUND AND RELATED WORKS

There are several challenges facing the integration of nanotechnology into the mainstream of undergraduate engineering curriculum. First, it is important to increase the awareness of high school and the first year engineering students about how the nanotechnology will shape our future. To this extend, Jones et al. (Jones et al., 2003) investigated the feasibility of allowing students in high school classrooms to conduct nanotechnology experiments through controlling remotely scientific equipments over the Web. Students had access to the nanoManipulator tool which gave them the ability to control an atomic force microscope over the Internet. The authors believe that most students were excited about the experience and developed more accurate concepts regarding nanometer scale as well as 2D and 3D virus morphology.

Another study funded by NSF focused on increasing the nanotechnology awareness for both high school and first year engineering students (Rodgers et al., 2013)showed that student had difficulties defining nanotechnology and its scale. This study also highlighted computer graphics, visualized sizing charts, and educational videos as effective techniques for helping students understand nanotechnology. Moreover, the study showed that connecting nanotechnology to various science and engineering fields could serve as a catalyst method for introducing and increasing students’ awareness and understanding of nanotechnology scope.

To reduce the anticipated lab cost, (Sarangan et al., 2013) suggested the use of a computer based nanofab trainer. The proposed trainer would allow students to practice real-life processes and tools as opposed to normal simulators used for predicting physical phenomena. They also proposed a multimedia system to bring live interactive demonstrations from existing nanotechnology laboratories and cleanrooms to the classrooms. Molecular Workbench software is another tool proposed by Xie and Lee (Xie and Lee, 2012) for teaching nanotechnology concepts. The tool provides a virtual laboratory in which simulated nanoscale processes can be examined and manipulated on a computer screen in real time. The authors conducted a pilot study iwhich showed that simulation-based experimentations can be successfully used for undergraduate students to develop an integrated understanding of concepts in nanotechnology at their own pace.

At the same time there are some efforts to incorporate nanotechnology into the mainstream of an undergraduate engineering curriculum. Uddin and Chowdhury (Uddin and Chowdhury, 2001) proposed the content of three fundamental courses to be integrated into an undergraduate engineering curriculum and suggested that the concepts of nanotechnology should be introduced during freshman and sophomore engineering courses. They also suggested modifying the outcomes of junior and senior design courses to include the modeling, simulation, control and optimization of nanodevices and systems.

However, the common factor in the above instructional design approaches is the lack of a standard platform for Web based education to create a space for educators to share experiences and to reach a wide community of learners.

Electronic learning production is multilayered as shown in Figure 1. The core layer is the learning object, which subsumes learning items following a standard vocabulary defined by IEEE LOM specification. Each item, in turn, points to a resource in the resources layer. As illustrated in Figure 1, some resources may reference files or contents outside the packaged contents through a URL.

Learning objects metadata is a standard structure to describe educational objects. The IEEE LOM stan-

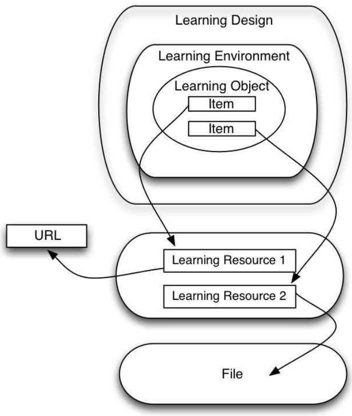

Figure 1: Learning Resource Layers.

dard specifies the vocabulary required to describe a learning object, so it can be used, re-used or referenced in technology supported learning. Learning objects typically incorporate contents to aid learners and education-providers carry out their activities. This content can be in a variety of electronic formats, including (X)HTML, RTF, PDF, or simply a URL. A learning object may be delivered within a specific environment such as a simulated laboratory application. Finally, a learning design may dictate the navigation through a sequence of learning objects. This process obeys a standard specification labeled IMS-LD (IMS Learning Design), which we will further present as part of our proposed framework later in this paper.

A learning object structure includes typical categories following an XML-based specification of LOM standard. This structure recognizes domain-specific requirements, which include a set of functional and non-functional capabilities that are deemed common to learner-assistant software agents. A LOM structure consists of the following elements which we used in our specifications: general, lifecycle, `Technical`, `Educational`, `Rights`, `Relations`. We particularly focus on extending the `Relation` attribute to mimic advocated pedagogical processes in nanoscale education.

3 LEARNING DESIGN FOR NANOSCALE EDUCATION

Current LOM metadata information need to be repurposed to explicitly represent the specification of nanoscale instructional units. This form of instructional units relies on semantic relationships between learning resources to introduce learners to nanomaterials (Manning and Monetti, 2013). Semiconductor design could involve bottom-up or top-down nanofabrication processes, using clusters of nanomaterial elements. This approach to the pyramid of education allows learners to advance through various disciplines that focus on phenomena and methods related to length scales (Roco, 2003). The objective is to provide a progressively comprehensive nanoscale education with connected and integrated knowledge to provide a holistic view, and a deductive understanding to learners.

Table 1: Relationships in Nano-Learning Objects.

Relationship	LOM element
Association	Requires
Aggregation	isBasedOn
Generalization	hasPart

Learning resources in nanoscale education, are structured as nano-learning objects, which describe structural relationships of learning content in order to support association and aggregation connections . These relationships could make use of the `Relation->Kind` element of LOM attributes, as shown in Table 1.

We define three types of relationships. The association relationship guides learners to prerequisite knowledge, whereas the aggregation relationship defines “the degree to which a digital learning resource is made up of other digital learning resources” (National Science Foundation, 2004). Finally, the generalization relationship refers to content assets or subtopics.

Collections of learning objects can be further organized and sequenced to form a learning component, which refers to a lesson or a course. Sequencing learning objects could be modeled through the use of a learning design language, such as the IMS-LD (for Learning Design), developed by IMS in 2003 (Koper et al., 2003). The conceptual structure of learning design is based on a set of concepts or building blocks that support the interaction among roles, activities and environments. In the case of the IMS-LD, each person may be assigned a role (either a learner or staff). Based on the assigned role and the specified learning goal, each person performs an activity within a specific environment. This could be for example a particular experiment in a simulated laboratory environment. The activity may involve both the learner and a remote laboratory staff. Our proposed hierarchical learning processes are based on IMS-LD standard, which sequences learning objects using the aggregation or generalization links for bottom-up or top-down learning designs. Each learning object may further be explored through association links.

Teachers and instruction designers need a specification of nanoscale education to express related learning activities. An IMS-LD compliant specification lends itself to be used by existing graphical authoring tools and engines to play the resulting specifications (Griffiths et al., 2008; McAndrew et al., 2005). To facilitate nanoscale learning developments, we propose ready-made templates that can be further refined to create finished modules (called learning units). These templates guide instructors and content providers to build structured learning contents. We call these templates Nanoscale Learning Design Patterns (NLDPs). They are analogous to Web page templates (e.g. available in Microsoft Front Page) to produce finished Web pages as content and structure are separated. Figure 2 illustrates this IMS-LD based learning design pattern for our nanoscale education model. NLDPs could be implemented using an appropriate editor. The provision of a dedicated high-level nanoscale learning editor supports teachers in the process of creating nanoscale learning units by starting from existing patterns.

The successive levels in the proposed learning design reflect the progressive bottom-up or top-down content coverage. Each levels is supported by a set of activities, which involve either learner or supervising staff. The environment entity indicates the experimental setup to carry out those activities, such as a simulated laboratory as discussed earlier in Figure 1.

4 SEMICONDUCTOR DESIGN INSTRUCTION

College students should get first-hand experience on how to fabricate various types of nanodevices and how to use them to design functional nanosystems. Therefore In additional to the classical CMOS processes, the proposed cyber-infrastructure containers should include learning objects with resources to introduce learners to carbon nano tubes (CNTs) and their unique properties such as their extraordinary strength and thermal conductivity. This learning object also includes resources to explore the electrical properties of CNTs and their usage as field effect transistors (CNTFET). Another learning object embeds motivational resources on the latest developments in semiconductor nanowires and their vast applications as logic devices, photo-detectors, biomedical sensors, thermoelectric generators, and memory devices. Subsequent (optional) learning objects could be used to introduce students to other types of nanodevices such as molecular resonant tunneling devices , single electron transistors , quantum-dot cellular automata devices, or any other future nanodevices as they become more developed and practical. These learning objects form the electronic repository of resources which is structured following the framework presented in Figure 1.

The cognitive navigational process through learning objects and their underlying instructional environments follows the methods used to fabricate the above mentioned nanodevices. These methods and hence the proposed learning path could hierarchically follow bottom-up or top-down approaches. Bottom-up methods are those where the nanodevices are gradually assembled starting from the atom and the molecular levels in an additive fashion until the desired device is built. On the other hand, the top-down methods start from a bulk substrate and use imaging and etching processes to sculpt the device.

The top-down method relies on using several photolithography phases to engrave devices on a substrate and connect them together to realize a specific circuit design. Each photolithography phase usually consists of several steps , which we put together using "`hasPart`" attribute (see Table 1) of LOM's relation tag.

The photolithography process is very mature as it has been successfully used by the semiconductor industry since 1970s. However the resolution of the photolithography process is limited by the wavelength of the light source used in the process. Current photolithography process uses deep ultraviolet 193 nm laser and liquid immersion techniques along with optical proximity correction to achieve feature length less than 20nm. In order to use the lithography method for future nanodevices, novel processes are needed to reduce the resolution further to few nanometers. Hence, in addition to the classical photolithography, additional learning objects could include scanning, scanning probe, e-beam, soft, nanoprint, nanosphere, and colloidal lithography techniques.

As a result of the massive government and industry investments in nanofabrication research, several bottom-up fabrication processes have matured over the last decade. This suggests an alternative navigation approach of learning objects with relation tag value set to "`isBasedOn`" to aggregate composing learning objects together. These processes and hence the induced instructional navigation can be divided into chemical synthesis and self-assembly ones. Self-assembly processes aggregate learning objects about molecular self-assembly and DNA-scaffolding processes. The chemical synthesis processes, on the other hand, aggregate learning objects on gas-phase and liquid-phase resources to manufacture nanoparticles. The gas-phase subgroup may further aggregate learning objects that illustrate the details of

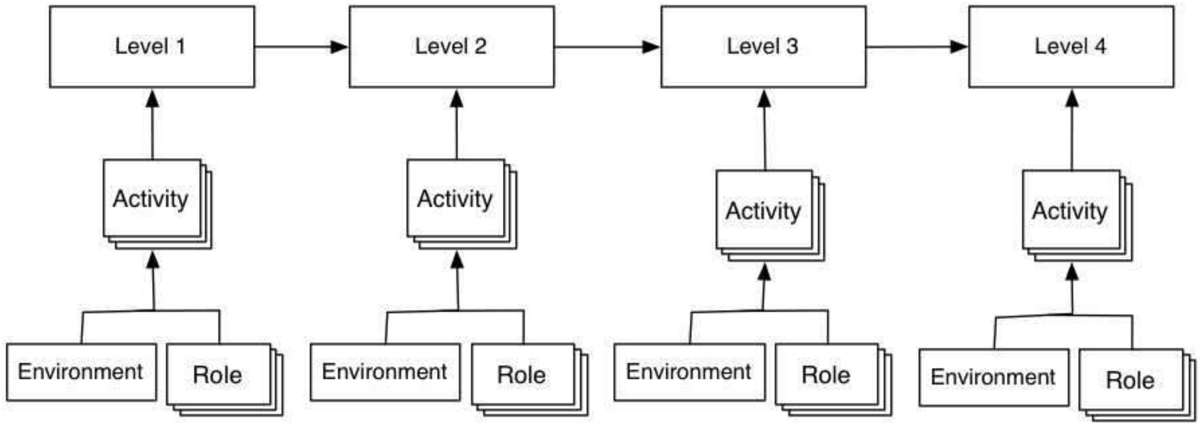

Figure 2: Nanoscale Learning Design.

atomic layer deposition , physical vapor deposition , and chemical vapor deposition processes. Similarly, Sol–gel , and liquid-phase epitaxy learning objects could be included under the liquid-phase subgroup.

It is obvious that the proposed learning objects mentioned above are highly interdisciplinary. The educational material covers a wide range of topics including engineering, chemistry, physics, material science, and biology in case of molecular self-assembly and DNA-scaffolding. Having these learning objects correlated in a bottom-up and top-down approaches following the navigational structure shown in Figure 2 organizes the contributions from instructors and scientists across multiple disciplines. The open Web design structure offers also interaction opportunities and best practice sharing of instructional scenarios among instructors Worldwide. Figure 3 shows the hierarchy of nanofabrication learning objects and their navigational sequence across the proposed cyber-infrastructure design container discussed earlier in Section 3.

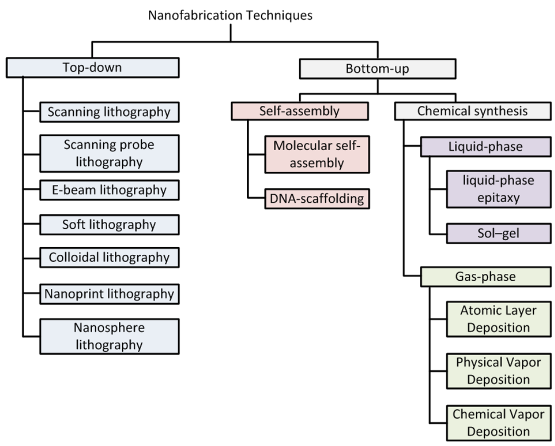

Figure 3: Nanofabrication unites proposed for inclusion in the cyber-infrastructure containers.

In addition to the top-down and bottom-up processes, there are also few other processes such as block copolymer lithography (Bates et al., 2013)that combines the bottom-up self-assembly process with top-down lithographic one, which calls for further customization of the learning design structure shown in Figure 2.

5 CONCLUSION

In view of the current shortage in nanotechnology educational resources, we proposed standard Web-based structures and processes for instructors to share educational material and for learners to personalize their learning experience in nanotechnology. The novel learning structure extends the current LOM metadata to explicitly represent the specifications of nanoscale instructional units based on expanding the standard `Relation` tag of LOM standard with three attributes: `Requires`, `isBasedOn` and `hasPart`. Following this design structure, we also adopted standard learning processes based on IMS-LD information model, that we specifically tailored to accommodate the processes of navigating through nanotechnology instructional material. To illustrate our approaches, we proposed a semiconductor design case study which we mapped on the proposed learning structure and processes to assist instructors sharing and reusing learning resources via the pervasive Web. The aim is to facilitate the integration of nanotechnology learning resources into the rising social trend of massively open online courses (or MOOCs) to benefit a larger community of learners and thus advancing the future of nanoscale developments.

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Cloud-based Mash-up Authoring Tools for e-Learning

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Keywords: Cloud Computing, Authoring Tools, e-Learning, m-Learning, SaaS, Web Services.

Abstract: The objective of an e-Learning authoring tool is the creation of an accessible and reusable pedagogical content that is conforms to the existing e-Learning standards. We argue that this objective can be extended when the learning content is created on a multimodal SaaS authoring and publishing platform with an XML-based language for content and metadata description to satisfy instructional designers for a responsive interactivity coupled with rich and informative substance. This position paper presents a Cloud-services based solution for building a virtual and personal learning environment that combines a wide range of technology and tools for learning-content mash-up authoring and diffusion. The proposed service-based framework is intended to support lifelong learning content creation and to enable mash-up of various learning services and applications by adapting learning objects on desktop and small handheld devices.

1 INTRODUCTION

The current e-learning applications required large investments in infrastructure systems and professional staff to maintain and upgrade systems. It is envisioned that, in the near future, cloud computing will have a significant impact on the educational and learning environment, enabling their own users to perform their tasks effectively with less cost by utilizing the available applications offered by the cloud service providers (Hossain, 2012). Interest in cloud computing in the e-learning area is growing due to potential greater cost savings from scalable architectures and open source products, and the possibility of higher learning outcomes (Fernández, 2012).

Software-as-a-Service (SaaS) is a cloud service which provides software functionality through Internet and can help efficiently the management of web-based applications and pedagogical data in an e-learning and m-learning context. Recently, more and more e-learning tools are migrating to the cloud. For instance, e-learning developers access the content authoring tools over the Internet via a secure hosted system without thinking about IT configurations, software set-ups and licenses. Cloud-based pedagogical content authoring is an e-learning process that is free from the constraints of typical desktop solutions and offers many advantages. In this position paper, we introduce the concept of *e-Learning-Software-as-a-Service* for e-learning and m-learning content-editing, storing, content-adaptation and diffusion. All aspects of an e-learning or m-learning solution can be delivered using the Cloud-SaaS model, including Learning Course Management Systems (LCMS), authoring tools, and collaboration tools like webcasting and white boarding (Basal, 2010).

In this position paper, we present our research in an ongoing project organized as follows: in Section 2 cloud-based content authoring tools and evaluation criteria are discussed. Section 3 presents the developed cloud-based e-learning semantic authoring suite. Finally, Section 4 ends the paper with conclusion and future work.

2 CLOUD-BASED COURSE DEVELOPMENT TOOLS

The objective of an e-learning authoring tool is the creation of an accessible and reusable pedagogical content that is conforms to the existing e-learning standards. We argue that this objective can be done if the learning content is created on a multimodal SaaS authoring and publishing platform with an XML-based language for content and metadata description to satisfy instructional designers for a responsive interactivity coupled with rich and informative substance.

Authoring process is an essential part of learning process and is supported by a suite of authoring tools for text, hypertext, graphics, mathematics, chart, and questionnaire content creation; i.e., Learning Objects (LOs). The purpose of an LCMS is to define the learning process by using and reusing created and existing LOs. This is a design process that includes: determination of learning objectives; planning how to assess learner comprehension, and identifying content needed so the learner can meet objectives.

We advocate for an approach where the learning process and the creation process are managed separately and independently of each other, i.e.: (1) a LOs authoring process managed by a suite of authoring tools; (2) a pedagogical process of course building, assessment and content adaptation managed by a LCMS.

2.1 e-Learning Authoring

The course development authoring tools are complex programs (e.g. Lectora (Lectora, 2013), Captivate (Adobe, 2014), ToolBook (SumTotal, 2013), SmartBuilder (SmartBuilder, 2014), StoryLine (Articulate, 2014), etc.) that allows the integration of media objects and the creation of interactive learning materials. So many authors started e-learning content creation with *off-the-shelf* software e.g. word processors, spread-sheets, desktop publishing packages, graphics packages etc.

The most famous and readily available of these is PowerPoint, which is powerful and complex software for slides and multimedia presentations but with some limitations concerning different versions and their use in the e-learning domain. For instance, PowerPoint's interface is somewhat cumbersome when creating pedagogical sequences that integrate multimedia components (e.g. text, images, audio and video). A course is designed to be integrated in a LCMS. To be imported or exported into a LCMS an external interface-program (plug-in) should manage the PowerPoint non ASCII file format which is proprietary and different from one version to another (e.g. Microsoft Office, Open Office, Documents To Go, Kingsoft Office, etc.). This lack of internal format of PowerPoint does not contribute to the mobility and interoperability of pedagogical content. In this case, the learning object discovery process (LODP) is hampered by the lack of metadata. The reuse of a course or selected parts of a course by others is practically compromised because this authoring tool is not SCORM or LOs standards compliant.

Except PowerPoint, for course development, there is a list (Tools, 2012) of proprietary, relatively efficient with several multimedia functionalities but very complex and expensive cloud-based content authoring software tools. We comment a few, non-exhaustive examples:

- *Lectora* (Lectora, 2013) offers a suite of online web-based, collaborative authoring tools for e-learning course creation and publishing in a proprietary format with the possibility to export in Adobe-Flash and SCORM compliant format.
- *Easygenerator* is an online free authoring tool. This Microsoft Windows application stores all pedagogical content in the cloud. With the free version author can have courses in an online workspace and can import existing Power-Point presentations for course build of.
- *QuickLessons* (QuickLessons, 2013) is a SaaS-based content authoring tool, requiring the user to only have access to a web browser. This online collaborative platform includes also evaluation engine for assessments, digital repository to manage media files and LOs. The author creates courses using libraries of templates, so it does not need any programming and design skills. Authors can include existing PowerPoint presentations or export a course to Adobe-Flash format or in HTML5 files. Multiple export options are supported for offline, online, mobile and LCMS use including SCORM and AICC compliance.
- *ZebraZapps* (Allen, 2014) is a SaaS-based authoring and publishing platform. This authoring tool allows developers and non-programmers alike to create interactive applications quickly, as well as share, publish, and sell objects or entire applications.

Some activities in these software tools seem "easy-to-use" by limiting development options. For example, they might provide a set of predefined interaction templates for developers to fill with content. This is really useful if those templates reflect exactly the interactions that the author want to create, but if the author want to customize the output these tools appear very restrictive. In addition, these programs have a common drawback. The authors edit a full course in a proprietary format whose components are not metadata described and hard to discover thereafter. The publication in SCORM format in a LCMS dissolves completely the created content in the learning process.

In this paper, we propose a solution with twofold purpose: on the one hand, it aims at presenting an XML-based language for semantic description of a course. On the other hand, it proposes a cloud-based authoring tool to build learning resources applying the defined language. The proposed solution stores away natively courses and facilitates the reuse of parts of a course in other courses because these parts can be easy discovered by an XML-based search method.

2.2 Authoring Tools Evaluation Criteria

The main function of an e-learning authoring tool is to integrate different media and create interactivities required in a learning program. As mentioned above, a number of e-learning authoring tools have been developed with a wide range of functionalities: from simple (e.g. template-based) to very complex with its own programming language and multimodal user interface. These software programs are too complex to be used by an author who is not an IT or an e-learning specialist. Subsequently a large number of users expressed a real difficulty in using these tools.

It becomes clear that e-learning authors need simpler but powerful authoring tools that could lower the skill barrier and allow more actors (i.e. teachers, academic authors, e-learning system administrators) to participate in the development and customization process. Moreover, to be really useful these tools should be able to reduce development time, effort, and cost, by allowing the reuse, enrichment and customization of available learning contents (Capuano, 2009). This necessity has motivated research and development of MOOCs (Massive Open Online Course) making use of cloud-based learning tools and online tools as well as learning support specifically for LOs creation and sharing (Rizzardini, 2013). MOOC is an online course aimed at unlimited participation and access via the web.

In this paper we introduce some evaluation criteria essential for the appropriate operation of an e-learning authoring tool:

- The authoring tool should be easy to learn and use because, in general, the author is not a professional e-learning developer and his experience in multimedia application is limited.
- The authoring tool should have the capacity to integrate media objects in various formats in the learning content with maximum flexibility.
- For educational subjects such as mathematics, informatics and science in general, some of the contents involve mathematics equations, graphs and diagrams. The authoring tool should provide the functionalities for such content creation.
- The authoring tool should provide the possibility to create quizzes for learners' assessment.
- An authoring tool should not require authors any programming skills.
- The authoring tool should provide deployment method for a LCMS with SCORM compliance integration.
- The authoring tool should also provide many alternative deployment methods for standalone (XML, HML or PDF), or for the web publication without any content reproduction during the deployment stage.
- The authoring tool should avoid the proprietary format for e-learning content for a maximum interoperability and reusability of LOs. Otherwise the LOs discovery and composition process are doomed to failure.
- The authoring tool should be accessible as service with standardized web browser.

To these *technical* criteria, we add a key *technological* one: *cloud service-based e-learning authoring process*. The cloud authoring is free from the constraints of typical desktop solutions. Advances in internet technology make appear web-based tools with collaborative capabilities, but also with some limitations than advantages. Some web-based tools are cumbersome with an input process using templates and forms, which results in a limited creativity and flexibility. The pivotal advantage of cloud-based content authoring is not the number of connected users but saving time, reducing rework, and sharing learning content across all projects. Authors access authoring software over the Internet via a secure, affordable hosted system, and regardless of location they can make updates and reusing content to complete a course. The adaptation of a cloud-based approach brings many benefits and relieves the author from embarrassing task (Fernández, 2012).

We argue that an effective solution for a successful cloud-based authoring process passes by: (1) the choice of a common format for the totality of the course content, and (2) the choice of an accessible and reachable storage format for the course. We suggest a non-proprietary format for better LOs reuse and to facilitate the LOs discovery and assembly, i.e. XML-based. Once created, a course can be saved in a single XML document or as a collection of XML documents. According to the evolution of the course, authors may need to modify its content. Therefore, the correct operation of a collaborative authoring system imposes the storage of learning collections, possibly in an appropriate database, for a better reuse and diffusion of these documents. We suggest the choice of a native database (NXD) which allows the storage of XML documents in their native format. This choice, in opposition to that of a relational database, is explained by the nature of pedagogical documents which are of narrative type, i.e. *document-centric* and not *data-centric* that is typical for relational tables. NXD and RDB follow two very different approaches to managing data. The concept of XML documents is to keep all attributes for a given LO together as one entity so that it can easily retrieve or insert all the relevant information for an LO in one shot. This is mostly useful for complex LOs whose attributes would otherwise be spread over many relational tables in the RDB model. XML is also suitable for LO whose set of attributes can evolve over time, since XML offers schema flexibility. Although relational database products today provide built-in XML document and query support, NXDs are arguably the best choice for learning content and metadata storage. As far as the query language is concerned, XQuery is recommended. Interoperability and data integration with existing e-learning systems and LCMS can be done by the means of cloud-based services. This solution simplifies the LOs reuse and the process of LOs discovery. As side effect of this approach, we can see a marked improvement of interoperability between e-learning systems.

3 E-LEARNING AUTHORING AS A SERVICE

This section presents a solution for building a virtual and personalized learning environment which utilizes a cloud-based technology to create a service-oriented model for e-learning and m-learning application service providers and learners. The concept of *e-Learning Services-as-a-Software* is introduced as software distribution model in which applications are hosted by a service provider and distributed via the web. In this environment we can easily combine semi-structured data, stored in a native XML database (NXD), with structured data stored in a relational database (RDB) through web services (WS). The objective is to provide direct data and application integration, located at distributed sites in order to improve the achievement of learning outcomes, i.e. integrate authoring process managed by a *cloud-service management system* (CSMS) (Fernández, 2012) with pedagogical process managed by a LCMS. This approach promotes a device-independent gateway between different units and the huge number of learning resources available on a plethora of LCMSs. A semantic content adaptation service is plugged for content standardization. It becomes possible by combining the *web-based open semantic editor suite* (WOSES) (Madjarov, 2011) with a set of additional cloud-services to allow different mobile units a direct access to LOs customarily designed for desktop web browsers. An alternative service is available for a speech solution, which allows learners to turn any written text into natural speech files, when using standard voices. This approach allows the generation and the progressive downloading of text and audio based learning material dynamically for m-learning and ubiquitous access. As result, we cover the essential part of introduced criteria in section 2.2. Details are presented in the following section.

3.1 e-Learning Authoring Tools

The tools we developed are inspired by mashing-up principles allowing an easy and fast integration, over defined schemas, of local and remote resources.

Xesop is an open source authoring software (Madjarov, 2012) that provides a flexible XML-based suite of tools for author customization, editing, storage and publication of LOs compliant with existing e-learning standards. The content aggregation specification comprises two models: a metadata model specifying the metadata elements of learning resources, and a content packaging model representing content structure. Both are hierarchical, which is convenient for representing data consisting of many elements and sub-elements. XML is perfectly suited for representing hierarchical models, as exemplified by the LOM and content packaging XML binding specifications published by IMS, both of which are adopted in SCORM.

In Figure 1 the structure of the created course with the Xesop project's semantic tools is presented. The original LOM structure is extended with new elements that seem important for more homogeneous and identifiable pedagogical content. For encoding textual information and content assembly, an XML semantic editor is developed (Figure 2) and a tree structure of a generic learning document is generated, while a validation grammar of XML schema type is used. Depending on course specificity, (mathematics or informatics course and science in general), the author can represent texts, diagrams, mathematical formulas or data in tables. A MathML editor was created for mathematical expressions, a SVG editor for vector graphics creation (Figure 3), a QTI editor for student's progression evaluation, a schema for table generation and a chart editor for data presentation. In this case, XML is used for encoding non-textual information such as vector graphics and mathematical expressions.

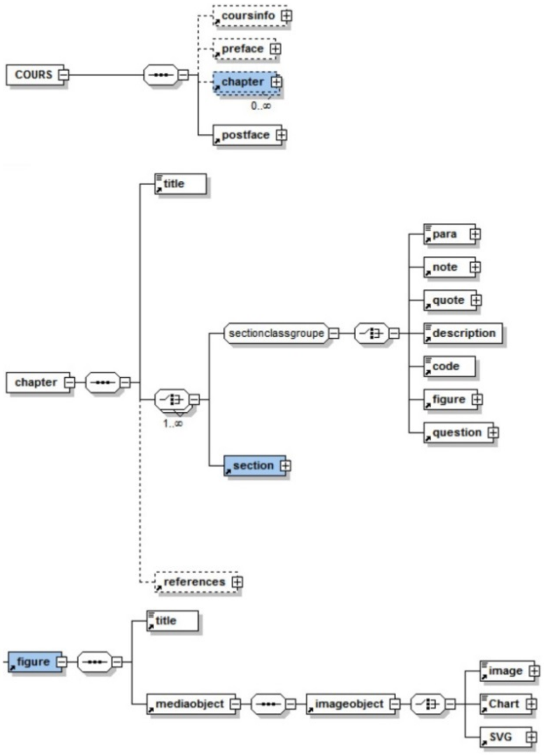

Figure 1: An extract of the Xesop course semantic.

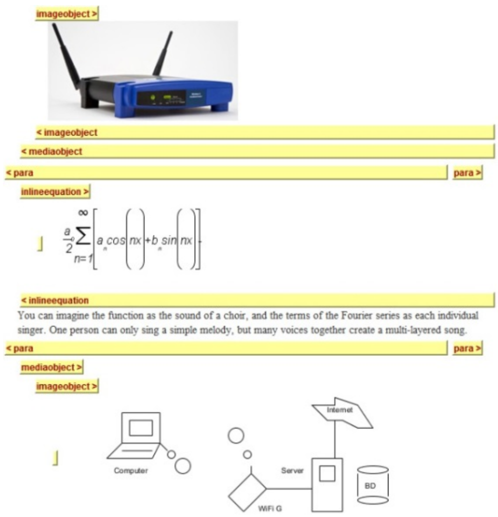

Figure 2: Xesop XML semantic editors.

In our e-learning authoring suite, binary data of multimedia content is embedded directly into XML course content. During the editing process, if the author inserts an image or any binary data into the edited content, the semantic editor will encode it using the Base64 encoding method. As a result, the course collection can be managed easily since all materials relating to the course are stored in a single XML collection (Figure 4). For more flexibility

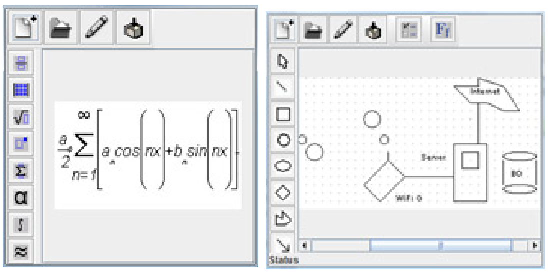

Figure 3: MathML and SVG plug-ins.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<COURS>
<coursinfo><title>Wi-Fi</title>
<date>24/12/2010</date></coursinfo>
<chapter><title>Introduction</title>
<para type="Wi-Fi hotshot">
Wireless network  ....
</para>
<figure><title>LinkSys</title>
<mediaobject><imageobject><image height="131" name
="wirelessrouter.jpg" width="250">
/9j/4AAQSkZJRgABAgEBLAEsAAD/4Q7rRXhpZgAASUkqAAgAA..
AAJAA8BAgAGAAAAegAAABABAgANAAAAgAAAABIBAwABAAAAAQAA
ABoBBQABAAAAjQAAABsBBQABAAAAlQAAACgBAwABAAAAAgA
................
FV46fs5EqqDv/AAyJVZ9/TAr/AP/Z</image>
</imageobject></mediaobject></figure>
<para type="Transformation">
None of this ....... written:</para>
<para type="Fourier transforms">
<inlineequation>
<MATHML layout="BLOCK"><math>
<mrow><mfrac><mrow><msub><mrow><mi>a</mi>
</mrow><mrow><mi>0</mi></mrow></msub></mrow>
<mrow><mi>2</mi></mrow></mfrac><munderover>
<mrow><mtext>&#x2211;</mtext></mrow>
......................
</mo></mrow></math></MATHML>
</inlineequation>
</para><para type="WiFi schema">
<mediaobject><imageobject>
<SVG><svg height="160" width="450" xmlns=
"http://www.w3.org/2000/svg"><g style="fill:none;
stroke:rgb(0, 0, 0); stroke-width:1"><path d=
"M330 50 L330 50 L330 50 L330 50 L330 50 L330 50
L330 50 L330 50 L330 50 L330 50 L330 50 L330 50
L330 50 L330 50"
.............................
stroke:none" x="330" y="20">Internet</text> </g>
</svg></SVG></imageobject></mediaobject>
<strong>Fig.1: General Wi-Fi schema connection
</strong></para>
</chapter>
</COURS>
```

Figure 4: Course XML collections.

and content reuse, author can separately save different elements of the course as LOs in the NXD as XML collection with multiple files.

A large number of media-rich content can be stored using the abundant set of available XML schemas. By providing proper XSLT transformation files, the XML content can be presented in many forms, such as HTML5 for web-based desktop or mobile users. If necessary, formatted HTML and PDF versions of extracted learning content can be published in a LCMS via web services. Existing and old pedagogical documents can be adapted in the compliant XML format via importing web services as external input in the XML semantic editor. M-Learning pedagogical content can be given in the form of a visual presentation as text, pictures, tables in XML, responsive HTML5 format or as PDF data. Optionally, m-learning content can be given as sound data in the form of an acoustic presentation in an MP3 or WAV format (Madjarov, 2012).

3.2 Implementation Scenario

The implementation scenario highlights the WOSES cloud-based application integration with a LCMS. The interconnection is carried out by a *web services management system* (WSMS). In our scenario, the *learning-centric data* and the *management-centric data* are clearly separated. Pedagogical documents are developed in WOSES framework of the *e-Learning Services-as-a-Software* based *Xesop* system and thereafter are stored in a NXD. The information relevant to learner personal data, learner profiles, course maps, LOs sequencing, data presentation and general user data is stored in the RDB of the LCMS. The publication process of learning content is carried out by WSMS. This allows integration existing LCMS systems via a cloud-based service. In the discussed case, web service-based modules make the bridge in a simple and effective way through Apache Libcloud, an open source library that provides a system-neutral interface to cloud provider APIs. The Java version supports Amazon EC2.

For system deployment, we used AmeTice (Moodle-based) e-Learning system deployed at Aix-Marseille University. Our system is based on the Apache containers suite for data storage and service management. We integrated the PHP-based LCMS interface via web services. For services deployment we used Apache Axis. For storing and managing LOs, we used eXist running in the Apache Tomcat Servlet engine as a web application and invoked via REST-style web services API. To integrate with other e-Learning and/or m-Learning systems we implemented an Apache jUDDI registry.

4 CONCLUSIONS

The developed Cloud-SaaS solution makes possible to create adaptive and responsive e-learning courses. Authors need to follow, in general, four phases of course development. To satisfy the phases of analysis, design, development and updating a free XML authoring language is used. The developed editor suite provides high-level WYSIWYM visual tools and enables a complete course to be designed without writing any programming code. We believe that a future cloud-based e-learning system should consist of a set of independent but cooperating non-monolithic services-based applications that integrate pedagogical data between common LCMS.

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Here's Looking at You, Player
The Potential of Eye Tracking Analysis for Player-centered Learning Game Design

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Keywords: Game-based Learning, Serious Games, Evaluation, Eye Tracking.

Abstract: There is no doubt that technology enhanced learning, in general, and game-based learning, in particular, needs thoughtful preparation, a careful design and a reliable implementation to meet the expectations of impact. But e-learning systems and serious games are digital media which usually are perceived very differently by different human learners with individually varying background and experience and within varying contexts. Perception and impact of media are a very delicate issue to be investigated carefully on a firm scientific basis. Digital games designed and implemented for special purposes of learning are particularly difficult to evaluate. Eye tracking is a technology suitable for the analysis of essential features of media perception which are relevant to learning. Eye tracking human learners' interactions with a serious game allows for the detection of substantial phenomena crucial for the design of game playing experiences likely to foster learning processes.

1 THE AUTHORS' POSITION

"Here's looking at you, kid." is a citation from the classic movie *Casablanca* by Michael Curtiz, 1942, starring Ingrid Bergman and Humphrey Bogart. The malapropism "Here's looking at you, User." is due to Christian Wolff[1] in his 2009 lecture on eye tracking in human-machine interaction. For the present paper, this idea has been adopted and adapted to direct the reader's attention to eye tracking of human game play.

The authors' particular focus is on game-based learning (Prensky, 2001). Undoubtedly, play takes a significant place in the development of humans and animals allowing for risk-free exploration and experiment. But contemporary serious games largely fail in meeting the high expectations of game-based learning (see, e.g., (Jantke, 2006a), (Jantke, 2007)). The state of affair is harshly, but felicitously summarized by Simon Egenfeldt-Nielsen in his book on the potential of serious games as follows: "Edutainment started as a serious attempt to create computer games that taught children different subjects. Arguably, it ended up as a caricature of computer games and a reactionary use of learning theory." ((Egenfeldt-Nielsen, 2007), p. 42) There is a necessity to abandon this state of affair.

There is abundant evidence for the need of a wide spectrum of methodologies and tools supporting formative evaluation of the design and implementation of serious games.

The authors' position advocated throughout the present paper is *to employ eye tracking analysis for the improvement of learning systems development, in general, and of serious games, in particular.*

According to the authors' very best knowledge, there is not yet much systematic usage of eye tracking in the process of designing and implementing digital games suitable for serious purposes such as training and learning.

The authors' opinion advocated by means of the present conference contribution relies on a variety of serious games developed and implemented by their team (see, e.g., (Jantke, 2006b), (Gaudl et al., 2009), (Jantke et al., 2009), (Arnold et al., 2013), and (Krebs, 2013) including the usage of eye tracking analysis.

The aim of the paper includes some *exemplified application of eye tracking analysis applied to some serious game project.* There is a number of qualitative questions to be answered.

In the authors' opinion, *the usefulness of eye tracking analysis for player-centered learning game design and implementation can be demonstrated.* This completes the positions to be advocated below.

[1] http://www.uni-regensburg.de/sprache-literatur-kultur/medieninformatik/sekretariat-team/christian-wolff/vortraege

2 INTRODUCTORY EXAMPLE

In the following example, an eye tracking study on the playing behavior in the serious game “1961” will show how gaze data can provide insights in the very individual as well as common procedures of the players when using a game-based learning application. With the eye tracking system it is possible to follow the subjects’ visual attention on the screen. This allows for a better comprehension of the users’ game play and bears the potential to indicate where and when learning processes may be stimulated.

2.1 Learning by Game Playing

Digital game-based learning unites serious learning and interactive entertainment. This is done by using the fun of gaming for motivating players who get concerned themselves with serious real world problems (see (Prensky, 2001)). The focus is primarily on the real action which is a basis for learning by doing.

In the point & click adventure game “1961” by Anja Hawlitschek completed at Fraunhofer IDMT in 2011, e.g., the player finds himself on some virtual journey back in time to the virtual year 1961 on the virtual Sunday, August 13, in the virtual Berlin when the Berlin Wall was built (Hawlitschek, 2010).

Figure 1: Experiencing life in Berlin in the game “1961”.

What is real in the virtual world of “1961” are the arguments in the virtual characters’ utterances, the problems addressed, and the positions advocated. The virtual world of the game is wrapping the real learning contents (Jantke and Lengyel, 2012).

With the digital game “1961”, the virtual world opens up the player’s access to this time. Virtual conversations of affected people confront players with real problems, arguments, and positions of that time. Different perspectives at the conflict are provided. Accordingly, those conversations are key to learning.

2.2 Didactic Approach

The underlying didactic concept of the game “1961” is based on the model of experiential learning and thus includes self-experiencing and the reliving of events. But for real learning, you need real aspects that are presented in the virtual world. Thus, the players find in “1961”, e.g., virtual original documents such as a newspaper or pictures of that time with real content for a better authenticity complementing the content of the people’s dialogs.

Utterances of virtual characters occurring in the game world of “1961” are designed in such a way that every utterance represents particular contents such as, for instance, a certain social problem, particular economic deficiencies and their impact on daily life, or some political opinion or perspective of that time ((Hawlitschek and Niegemann, 2013), sec. 2, table 1).

The player is not given a specific learning goal, but has a clear game goal, i.e., to find a charged battery to, once more, reach the present (see (Hawlitschek, 2010)). While playing the user gets to know different arguments by the game characters. The true learning contents, so to speak, is presented implicitly and learning is assumed to take place partially unnoticed.

2.3 General Assessment

In general, learning success can be achieved especially based on experimentation, exploration and self-experience. The player gets implicit information about the former “world view” through the virtual communication built on the real arguments of the characters.

First evaluations of the game “1961” investigated usability matters, effectiveness in terms of pedagogical aims as well as game experience and cognitive processes. Positive correlations between motivation and learning success could be reported (see (Hawlitschek and Niegemann, 2013)).

Subsequently, a first exploratory evaluation which was carried out by using an eye tracking system in November 2013 now provides further information on the game design. Adolescents aged from 14 to 16 years who belong to the target group of students attending history classes in secondary school level in Germany took part in the play testing. The exploratory study could benefit from the eye tracking method concerning research questions that considered aspects like, e.g., the decision behavior with respect to the chosen ways to interact with entities, how much time the players dedicate to certain entities, or how entities and dialogs are perceived. Thus, an approximation to understanding gameplay takes place.

2.4 Observations by Eye Tracking

The overall interest of this research is to gather hints *where and how implicit learning in the game "1961" might take place* and how new re-arrangements could help to improve the game-based learning setting. Therefore, the goal of this first and short exploratory evaluation using the eye tracking system was to examine to what extent the test persons follow the factual content and which persons and objects are focused and with which intensity, e.g., by using instruments of fixation count, gaze duration, time to first fixation and scan paths. The focus of the evaluation was on *how dialogs are perceived and under what circumstances they are read by the players*. Therefore, the gaze behaviors of persons who are provided with dialogs were studied. It was of special interest what the players perceived (which objects were focused and how often), which dialogs were requested and how these retrieved dialogs were read (which, how often and how long, which words were focused in which order, e.g. looking jumps and repetitions). Different characteristics could be found and will be described in detail with reference to one exemplary scene.

In the chosen scene (see figure 1 in chapter 2.1) the woman at the window gives information about ways to find the charged battery leading back to the present on the one hand, and about the impact on people's daily lives through the construction of the Wall on the other hand. Furthermore, there is a little girl and two women speaking who are outraged by the construction of the Wall. Some text information are automatically displayed in this scene and thus automatically appear to the player. Other dialogs however have to be actively requested by the user through exploring the characters by clicking on them.

During the exploratory analysis of the eye tracking recordings three different behaviors of handling the dialogs in the game could be observed. The characteristics of the detected ways of text perception are described in the following paragraphs and roughly confirmed in the exemplary excerpt of the data.

Characteristic 1: No Text Perception. Regarding the data, subject 4 did not request any dialog at all in this scene (see figure 2). No interactions except walking around took place. But the eye tracking data confirm that the characters as well as automatically displayed text were fixated several times by this player (see figure 3).

Characteristic 2: Minimum Text Perception. Subject 3 also spent some attention on the characters and texts in this scene. In comparison to subject 4, some further dialogs were chosen to be read additionally, but perceived only in a limited number (see figure 2).

Characteristic 3: High Text Perception. The scene was explored in great detail by subject 1 and 2 what is shown in the high number of clicked dialogs (see figure 2)–and more importantly–in the high number of fixations (see figure 3). In the given example high fixation rates are an indicator of larger numbers of words read by the player what was also confirmed by the scan path analyses.

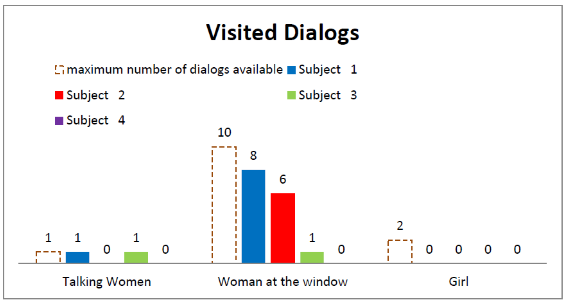

Figure 2: Dialogs retrieved by the subjects (click data).

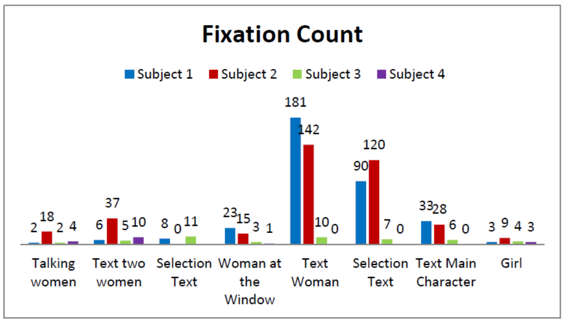

Figure 3: Some differences in attention are visible in the fixation counts (eye tracking data).

Altogether, these different ways of perceiving (additional) textual information detected during the study

- no text perception,
- minimum text perception, and
- high text perception

gave an insight in how several items that are important for achieving learning goals are dealt with. A questionnaire and an interview with the test subjects confirmed the eye tracking findings and investigated some reasons for the playing behavior such as, e.g., a very goal-oriented strategy of subject 3. This led the player to look only for promising information in order to make fast progress in the game–but prevented him from experiencing more interesting details which are part of the learning goals.

In addition, it was possible to show what objects (dialogs, words, objects or persons) had an impact on the game behavior. For instance, in figure 4 it is shown how single items like words within a dialog can lead into the game world. The scan path in this example demonstrates that stimulus words from the woman's monologue are searched in the game world such as, e.g., "shopping" or "crisis". The objects belonging to these keywords were strongly focused by the subject's eyes and thus gained the necessary attention to become part of a learning process at all. With the eye tracking data it became possible to see, e.g., the order of words read, long lasting considerations or keyword-oriented playing.

Furthermore, the data show that some characters are addressed more often than others, e.g., the test persons did not speak to characters like the girl in the middle of the scene in figure 4, although it has been fixated before by all of the subjects (figure 2 and 3). Changes in game design like animating the girl could open up the contact to this character. Only content gathering attention can become part of implicit learning processes. Eye Tracking supports analyzing where learning becomes possible at all as it shows learners' real actions such as reading and watching which build a fundamental precondition for learning.

Figure 4: The scan path shows how stimulus words lead into the scene.

To sum up, the authors' experiment reported above has been demonstrating that eye tracking works, at least, for purposes such as identifying substantially different behaviors of play which correlate with success or failure, respectively, in perceiving information crucial to human learning to be fostered by the serious game under consideration. Roughly speaking, it turned out, e.g., that players who act too stringently towards success of game play are likely to miss substantial information needed for learning.

The implications for game design and revision are manifold. Insights arrived at by means of such an eye tracking analysis may lead to changes of the game mechanics, to modifications of the visual experience, and to game adaptation to varying styles of play.

3 POTENTIALS OF THE TECHNOLOGY

Game-based learning applications have to fulfill some elementary expectations concerning the user's gameplay experience on the one hand, and didactic intentions on the other hand that might strongly vary from the context of use of a serious game as well as from the user's knowledge, skills and former experiences. In general, eye tracking can help to inspect game play experiences and can also be used, to some extent, to regard and evaluate the impact of didactic arrangements. In this way, it can give feedback to designers and developers of learning games. The short exemplary eye tracking study on "1961" has shown just an entry to reasonable employment of the eye tracking method in the process of serious game development.

Basically, eye tracking is widely known as a technology to uncover usability matters of software applications–very often in terms of website design as it is described by (Nielsen and Pernice, 2010). But there have already been a variety of studies applying eye tracking to digital games as well. This definitely took greater efforts according to the complexity of games as dynamic stimulus, but clearly showed the benefits of eye tracking when evaluating selected game aspects (see, e.g., (Almeida et al., 2011), (Buscher et al., 2010), (Johansen et al., 2008)) that might impact on the player experience. It became possible, for example, to detect preferred watching regions on a screen, unremarkable objects in a game and even differing attentional progresses of inexperienced and hardcore gamers. Furthermore, some attempts were already made to retrace phenomena of game play within exploratory studies like the feeling of immersion or engagement (see, e.g., (Renshaw et al., 2009), (Jennett et al., 2008)), however, still lacking greater examinations, a clear validation of results and systematization of the findings according to intervening variables. Furthermore, it is a highly interesting way to get insights into the interdependencies of game design and the mechanisms of game playing behavior by different users that will enable us to implement didactic concepts in serious games.

After more than one decade of intense eye tracking research some promising novel approaches came up lately that show some first creative enhancements:

Gaze Data Representation. Visualization approaches that allow new insights into the gaze data will lead to more specific results and also to further questions. For example, illustrations like so-called *space-time-cubes* (Kurzhals and Weiskopf, 2013) directly uncover trends in viewing behavior and sequences of attentional synchrony of several users. *Superimposed 3D scan paths*, *three-dimensional attentional maps* or *models of interest timelines* (Stellmach et al., 2010) allow detailed multi-perspective inspections of views at 3D environments. At this moment, the exact potentials for examining game play using these techniques are not explored, yet. Nevertheless, even more creative approaches might be needed to face the analysis of those highly individual game play recordings with gaze tracking.

Systematization of Gaze Patterns. Although looks are always depending on the tasks users are performing (see (Nielsen and Pernice, 2010), p. 13 ff. and p. 422 ff.), there are some helpful collections of often shown gaze behaviors, e.g., the so-called f-shape when reading web content. Further existing registers like Ehmke et al.'s *summary of eye-movement metrics related to usability problems* and the derivation of *eye tracking pattern generalizations* (Ehmke and Wilson, 2007) have to be very carefully interpreted because of missing validation, but might give a hint on user's gaze behavior when using websites. Systematized eye tracking in serious gaming contexts could open a wide area of application and make game play experience in manifold cases more comprehensible and, thus, in terms of game-based learning, easier to anticipate.

Feedback on Gaze Patterns. Besides concepts directly using gaze control for steering digital games there are some interesting game input mechanisms like in the prototypically implemented horror-game "Sophia" [2] (status 2013) that uses the *recognition of eye tracking patterns while playing* as a parameter to influence the story and–in this case–to terrify the player by unexpected incidents. Seen from a didactic point of view, concepts like this provide many ideas to implement situations adequate for implicit learning.

Linking Gaze Patterns to Storyboards. In terms of achieving player-centered learning game design, eye tracking might become one key tool (among others) to inspect crucial game sections and create appropriate story alternatives upon the results. This was basically shown in the introductory example on "1961" (see chapter 2) when the progress of attention on learning-relevant objects has been analyzed.Future research by the authors will examine, if and how such findings can be implemented in a digital storyboarding system that allows to anticipate different user-centered learning experiences by means of user modeling and adaptive system behavior. Potentially, eye tracking could contribute to game-based learning scenarios that provide customized didactic patterns underlying a human user's game play–just as he freely explores a scene by playing.

[2] http://www.uni-regensburg.de/pressearchiv/pressemitteilung/302195.html

4 LIMITATIONS OF THE TECHNOLOGY

While eye tracking is already well-known by website developers and is also partly becoming of interest to the video games industry (see, e.g., (Almeida, 2012)) its potentials have not yet been systematically explored and extended to the field of serious gaming. When starting to discuss possible potentials of eye tracking to impact on serious games concepts several limitations have to be considered that underlie several reasons, such as:

- **Technological Limitations**
  - the fact of games being a special case of dynamic 2D- or even 3D-stimuli being controlled by indiviual users and causing individualized data in every session that can hardly be compared one to another,
  - missing automation that helps processing the huge amounts of individual data sets, e.g. in recognizing dynamic areas of interest (AOI) or finding object-dependent patterns in the gaze recordings, as well as
  - a "lack of suitable [analysis] techniques" that help to overcome time-consuming frame-by-frame-analyses like it is described by ((Stellmach et al., 2010)).
- **Methodological Limitations**
  - the necessacity of combining eye tracking data in carefully controlled experiments with additional data by further methods like retrospective thinking aloud-protocols (see, e.g., (Eger et al., 2007)) to extend the information value of the stand-alone-investigations,
  - still missing links in between eye tracking data and further data gathered to describe game play experience (Nacke et al., 2010) like using different methods like questionnaires, interviews, game metrics, psychophysiological player testing etc., and
  - missing validation of gaze patterns described in manifold exploratory case studies such as, for instance,(Ehmke and Wilson, 2007) and (Kivikangas et al., 2010).

To sum up, in order to spread eye tracking as a supporting method in serious game concepting further analysis tools need to be developed to face specific research questions as well as technical challenges, e.g. concerning the comparability of data sets, combination of eye tracking data with data of other sources and creative ways of visualising the gaze data to enable new possibilities of analysis and novel findings.

5 CONCLUSIONS & OUTLOOK

The authors admit that a comprehensive evaluation of "1961" based on eye tracking is still badly missing, to some extent, due to several issues raised in section 4.

The game "1961" has been used to exemplify the way in which eye tracking analysis may lead to some key insights into problems of serious game design. Missing utterances in "1961" is really a crucial issue.

Nowadays, eye tracking still is a costly, but in many fields valuable method to evaluate and support software development. Taking advantage from the eye tracking findings in the area of serious gaming in educational contexts, e.g., for offering individual player experiences or specific didactic approaches, is still open. Systematizing available findings and redefining requirements of eye tracking analyses will help fully exploring the potentials of the technology.

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The Educational Potential of Technologies for Older People
Reflections on the Well-being

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Keywords: Health Education, Active Ageing, ICT, Elderly.

Abstract: Worldwide life expectancy has increased over the last century. In Brazil the population over 60 years was approximately 10% in 2009, and it is expected to increase to 29% in 2050. This increase in life expectancy leads us to consider strategies that can assist in maintaining the quality of life during the ageing process. One strategy that must be considered is the health education to the elderly, so we construct a web application – Active Ageing TV – that is based on the reports of World Health Organization, and on the use of gerontology education to facilitate the learning process, and on the use of techniques to design according to specific characteristics of older audience. To validate our application, a survey was conducted with seniors who participated in a course of digital inclusion in Brazil, during 2009 to 2013. We used “Profile of Individual Life Style" instrument to evaluate the lifestyle perceived by the participants. Our findings indicate that seniors are looking for a preventive behavior, but information is necessary to assist them to make right decisions for a healthy lifestyle.

1 INTRODUCTION

Worldwide life expectancy has increased over the last century. In Brazil the population over 60 years was approximately 10% in 2009, and it is expected to increase to 29% in 2050 (IBGE, 2013). This increase in life expectancy leads us to consider strategies that can assist in maintaining the quality of life during the ageing process (Veras, 2012).

Human ageing is a universal, progressive, and gradual process. This process is different for each individual. There are a variety of factors that affect this process: genetics, biology, social factors, environment, psychology, and culture (WHO, 2002). Gerontology is “the scientific study of old age” and consists of the integration of conceptual linkages across the biological, psychological, and social processes of aging (Alkema and Alley, 2006).

In Brazil, gerontology is still considered a new science (Valadares et al., 2013), and is concerned with the implementation of actions aimed at improving the quality of life of those who are ageing to ensure autonomy and independence. In turn, educational gerontology refers to the use of a teaching method to facilitate learning in older adults through the exploration of the potential of this age group (Ala-Mutka et al., 2008; Ianculescu and Parvan, 2011; Kececi and Bulduk, 2012). In this sense, continuing education requires a combination of opportunities to encourage the promotion and the maintenance of quality of life for the elderly.

According to the Ministry of Social Welfare and Assistance in Brazil, "Ageing is a normal and dynamic process, and it is not a disease. While ageing is an inevitable and irreversible process, chronic and disabling conditions that are often observed with advancing age can be prevented or delayed, not only by medical interventions, but also interventions in social, economic, and environmental aspects" (Brasil, 1996, p. 1).

The term "active ageing" was adopted by the World Health Organization in 1990, and it is based on the recognition of human rights of older people and in the United Nations Principles of independence, participation, dignity, care, and personal fulfillment (WHO, 2002). The broad concept of quality of life points to the need to consider the aspects valued by the elderly related to overall well-being such as health, life satisfaction, and psychological well-being within the social and physical environment in which they live. Therefore, it is important to encourage a healthy lifestyle through a balanced diet, regular exercise, social interaction, enjoyable occupational activity, and mechanisms to mitigate the stress and avoiding smoking, alcoholism, and self-medication.

Self-care should be seen as the creation of new opportunities to respond to life in a safe and healthy way. For this reason, the issues addressed in educational activities must involve more than diseases and risk factors. Ageing, sexuality, leisure, family relationship, and social rights of the elderly, as well as numerous other factors that illustrate the needs and interests of the older population, are dimensions of life that must be considered to promote self-care (Sousa and Assis, 2012). The behavioral change to a healthy lifestyle is a key ingredient to encourage active ageing.

This paper is organized as follows: section 2 shows the literature review on health education; section 3 presents the Active Ageing TV application; section 4 the methodology used to test the comprehension about the content of Active Ageing TV is explained; and in section 5 are presented the concluding remarks.

2 HEALTH EDUCATION

Brazilians are living longer and this means that the Brazilian society needs to promote programs for the prevention and maintenance of health for the elderly. Because the promotion of such programs has not occurred, the ageing process of the Brazilian population is now largely characterized by the progressive accumulation of losses of functionality in activities of daily living (Veras, 2012). The trend is evident in the growing number of seniors who are functionally disabled and have poor health. The most common problems in elderly people are Alzheimer's disease, depression, osteoporosis, and falls. These problems show the need for an emphasis on health promotion and prevention of frailties (WHO, 2002).

According to Kececi and Bulduk: “the main objective of health education is to provide individuals and society with assistance so that they can lead a healthy life through their own efforts and actions. Therefore, health education supports and develops all kinds of individual learning processes. Similarly, it makes changes in the beliefs and value systems of individuals, their attitudes and skill levels; in other words, it changes their lifestyles” (Kececi and Bulduk, 2012, p.160).

The World Health Organization suggests that early education in life combined with opportunities for lifelong learning can help people to develop skills and confidence to adapt and maintain independence as they grow older. Learning is necessary to improve understanding (for instance, learning related to health issues) and to enhance capabilities for practical tasks (learning to use new tools like online banking or how to use assistive technologies to compensate for lack of functionality), and learn new activities.

The motivation to learn for elderly people depends strongly on the purpose of the learning outcomes, and also in how much they consider themselves able to achieve these results (self-efficacy). The commitment to meaningful activities for the elderly contributes to good health and satisfaction with life and longevity (Ala-Mutka et. al., 2008; Kececi and Bulduk, 2012; Ianculescu & Parvan, 2011; Serbim et. al., 2012). The success of health promotion can be evaluated by measuring to what extent the intended objectives can be achieved by target audience.

3 ACTIVE AGEING TV

We build a web application based on the WHO Active Ageing reports (WHO, 2002), conventions established by the field of educational gerontology (Alkema and Alley, 2006), and the use of style guides for interactive Digital TV for the elderly (Rice and Alm, 2008). The platform selected for this version of Active Ageing TV (Figure 1) is web based. Today smartphones, tablets, connected televisions and computers are all web receivers, which allow a greater range of choice by seniors.

Figure 1: Active Ageing TV (Envelhecimento Ativo TV) avaiable at http://envelhecimentoativotv.weebly.com.

Active Ageing TV focuses on information about active ageing and activities recommended for the elderly. Videos were used with content that includes physical exercises and strategies that guide seniors to make changes at home to meet their safety needs. Information about social networks and senior communities are also provided to give social opportunities for the elderly.

Active Ageing TV aims to inform and to provide resources in a variety of methods on how to maintain independence and quality of life during the ageing process, or, in other words to promote self-care to the elderly. So, to achieve this purpose the videos used were about the behavioral determinants defined by WHO (WHO, 2002) like:

- Physical activity – regular practice of moderate physical activity is essential for good health and to preserve independence of the elderly, helping reduce the risk of falls and related injuries (Figure 2).

Figure 2: Physical activity (Atividade fisica).

- Healthy diet – the maintenance of a balanced diet rich in calcium can reduce the risk of injury in the elderly (Figure 3).

Figure 3: Healthy diet (Alimentação saudável).

- Use of medications – the elderly tends to consume greater number of medications than younger people. As they age, people develop different mechanisms for the absorption and the metabolism of medications. If the elderly do not take their medications as prescribed by physicians, their risk of falls and side effects may be affected in different ways (Figure 4).
- Risky behavior – the choices that people make and the actions carried out can increase their chances of falling, for example, to climb ladders, to wear ill-fitting shoes, to bend over to perform everyday tasks, to run without being aware of the environment, or to avoid using artifacts to support mobility such as canes or walkers (Figure 4).

Figure 4: Stay tuned (Fique atento (a)).

- Social interaction – incentive to stimulate social interaction and conduct occupational activity as an enjoyable way to relieve stress and prevent depression and isolation (Figure 5).

Figure 5: Social interaction (Convívio social).

- Harmful habits – clarification about the consequences of harmful habits like smoking, alcoholism, and self-medication (Figures 2, 3, 4, 5).

In the Active Ageing TV application the user can access four modules: healthy diet (Figure 3), physical activity (Figure 2), social interaction (Figure 5) and stay tuned (figure 4). Each module has four videos extract by Youtube about the proposed content, and a section "Know More" that consists of a list of sites with more information about the subject of study, and a section "Interactive Test" that is a form to collect data about the user behavior on that aspect.

The videos used were selected from the reliability of its producers, such as universities, government or broadcast TV programs with affairs on health and wellness. One of the criteria was that the protagonists of the videos would be the elderly, and that the videos used were of short duration to allow a discussion on the subject after its display. This strategy makes a personal call to the elderly to participate actively and think about their behavior in health maintenance.

4 METHODOLOGY

We used qualitative and quantitative research methods focusing on the behavioral determinants adopted by elderly and its influence in their quality of life. The 12 seniors surveyed were 60 years or older and attended a course designed for digital inclusion at the Federal University of Rio Grande do Sul, Brazil between 2009 and 2012. We proposed a Quality of Life course during four weeks in November to December of 2013.

The seniors that have participated of our research have an age average of 68 years. The group encountered two times a week to study and discuss about modules of Active Ageing TV. Each elderly assisted the proposed videos individually and, after that, all participants were invited to explain and discuss with the whole group about what they learned, what they already do to achieve a healthy lifestyle and the strategies they used to do that. The researcher assumed the role of mediator in this educational practice, and it was created a participative environment in which everyone felt comfortable to show his/her ideas (Serbim et. al., 2012; Sousa and Assis, 2012).

After watching all modules, each subject was seen separately one per week, seniors were asked to reflect on their lifestyle. For this we used two instruments: (1) the "Profile of Individual Life Style" instrument (Both et. al., 2008) and (2) an individual semi-structured interview based on the behavioral determinants of active ageing (WHO, 2002).

The Profile of Individual Life Style Questionnaire (Both et. al., 2008) known as "The Pentacle of Well-Being", with a conceptual basis for evaluating the lifestyle of individuals or groups. This instrument consists of 15 questions, divided into the following factors: nutrition (factor 1), physical activity (factor 3), preventive behavior (factor 4), social relationships (factor 5) and stress management (factor 2), without regard to socio-economic factors, genetic heritage, political beliefs and other factors that may influence the results.

Of course the ideal would be that all items were completed at maximum level (corresponding to 3 points on the scale). Scores in levels zero (0) and one (1) indicate that the individual must be guided and helped to change his/her behavior in the items assessed, since they pose risks to his/her health. The general idea is to allow the person to identify positive and negative aspects in his lifestyle, getting information and opportunities to make decisions that can lead to a life with more quality.

In our research we applied the instrument individually and the senior received a copy of his/her responses to check what points he/she is doing well and the points he/she has to make efforts to get better results. The meanings of the responses are as follows: [0] never, [1] sometimes [2] often and [3] always. The results indicate that diet and physical activity should be improved. Like most of group is living alone (8) or has a problem of movement (4) or sedentary lifestyle. It demonstrates the difficulty in maintaining a varied diet or frequent physical activity.

Table 1: Factor 1 (Nutrition).

	[3]	[2]	[1]	[0]
a. Your daily diet includes at least 5 portions of fruit and vegetables	31%	23%	31%	15%
b. You avoid eating greasy foods (fatty meats, fried foods) and candies.	8%	46%	46%	0%
c. You do 4 to 5 different meals a day, including full breakfast.	31%	15%	39%	15%

Table 1 shows that 31% of group has 5 portions of fruit and vegetables in their daily diet. On the other hand, 46% sometimes avoid eating greasy foods and candies, and 8% always avoid this kind of food. Another factor that must be improved is the number of meals a day, 39% sometimes do 4 to 5 meals, and 15% never do that. These outcomes were reinforced with the speech of one senior: "*with the video I will try to insert more vegetables at meals; as I have reflux, I'm adapting my diet and I have already* *noticed better results; I started walking with a water bottle in my purse... ".*

Senior's speeches often lead to this: "*You think you know a lot, and maybe you know, but you do not practice; things we already know but it's always great to reinforce them; the elderly has resistance, he/she is more stubborn, but if explain the change and its benefits he/she can start to improve*".

Table 2: Factor 3 (Levels of Physical Activity).

	[3]	[2]	[1]	[0]
d. You realize at least 30 minutes of moderate to intense physical activity, continuously or cumulatively, 5 or more days a week.	15%	31%	39%	15%
e. At least twice a week you perform exercises that involve muscle strength and stretching.	23%	46%	23%	8%
f. In your day by day, you walk or you pedal for transportation and preferably use the stairs instead of the elevator.	15%	23%	54%	8%

In Table 2 we can see that although the elderly group performs physical activities, they do not do it in the frequency of five or more days per week. But, 23% perform exercises that involve muscle strength and stretching twice a week. And, we can see that sedentary lifestyle is represented in 54% of individuals that sometimes use to walk or to pedal for transportation, and prefer the elevator instead of the stairs. After looking at the results a senior said:

"*I'll promise to myself to start walking, because when I doing exercises I felt good and I did not need to take medicine for cholesterol that I need today*".

Table 3 shows that the group has a preventive behavior. They know their blood pressure, their cholesterol levels and they are looking to control them. But if the elderly look for to have a healthy diet and better levels of physical practices, their outcomes must be better. And Table 3 show too that the group don't smoke and drink alcohol with moderation, and they use seatbelt and never drink alcohol when they are driving.

Regarding to preventive behavior an elderly said: "*videos gave many tips on mobile, the height of the bed, etc., there are things that I already do, but I learned a lot, how to protect wires, take off rugs, things that can cause accidents. As I live alone I need to take care of myself*".

Table 3: Factor 4 (Preventive Behavior).

	[3]	[2]	[1]	[0]
g. You know your blood pressure, your cholesterol levels and you are looking to control them.	46%	54%	0%	0%
h. You do not smoke and you drink alcohol in moderation (less than 2 daily doses).	76,9%	7,7%	7,7 %	7,7 %
i. You always wear your seatbelt and if you drive, you respect traffic regulations, and you never ingest alcohol when driving.	85%	15%	0%	0%

In Table 4 we can see that seniors have an active participation in social life with family, friends and community service.

Table 4: Factor 5 (Quality of Relationships).

	[3]	[2]	[1]	[0]
j. You find yourself surrounded by friends and you are satisfied with your relationships.	77%	23%	0%	0%
k. Your leisure includes meetings with friends, group sports activities, participation in associations.	85%	15%	0%	0%
l. You try to be active in your community and you feel useful in your social environment.	67%	25%	0%	8%

Table 5 presents that they reserve at least five minutes to relax by day (69%). And in the most cases they can hold a discussion without change their mood, even when they are contradicted (54%). But, on the item of the balance between work and leisure we can see that the group has some difficulties to do that. Perhaps due to their creation that has always prioritized the work and effort in place of leisure.

Regarding the use of videos as course material, a senior said: "*Is interesting because you see the video, you can assimilate the teachings more. I get more attentive than if I have to read... I have history of falls and the information of the videos was very* *useful... I started to decrease the sugar and salt in meals, and I started buying more fruit*".

Table 5: Factor 2 (Stress Management).

	[3]	[2]	[1]	[0]
m. You take time (at least 5 minutes) every day to relax.	69%	23%	8%	0%
n. You hold a discussion without changing your mood, even you are contradicted.	15%	54%	31%	0%
o. You balance the time devoted to work with the time devoted to leisure.	15%	39%	46%	0%

The data considered here show a positive influence that Active Ageing TV application performs in quality of life and adoption of a healthy lifestyle by seniors.

5 CONCLUSIONS

This paper presented a web application to help to promote active ageing and adoption of behaviors by the elderly that lead to a healthy lifestyle. Our project was submitted to the Ethics Committee in Research of the Federal University of Rio Grande do Sul and was approved in accordance with the report number 137.267 in 2012.

Active Ageing TV application differs from others by using the educational approach as a strategy to inform and to educate the elderly, therefore encouraging them to become responsible for maintaining their own health throughout life. This is based on the concept of active ageing, as defined by WHO reports. Our intention is to disseminate the behavior determinants of active aging policy to help seniors to maintain their autonomy, independence, quality of life, and a healthy life expectancy. Our contribution focuses on the development of an application that seeks to encourage the adoption of guidelines for active ageing from the user perspective by promoting greater awareness of the importance of certain activities and lifestyle to improve the quality of life.

In fact, the lifestyle is one of the most important factors for maintaining health as well as to promote the extension of longevity of the population.

ACKNOWLEDGEMENTS

Jantsch A. is grateful to CAPES and CNPq for scholarship and financial support, as well she is grateful to seniors who participated in this research.

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Educational Application Design Process Experiences
Case Perioperative Nursing

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Keywords: Perioperative Nursing, Game Development, Nursing Competencies, Learning Objectives, Educational Application Success.

Abstract: From an educational point of view, the only relevant basis for the design of an educational application is the learning objectives of the content area. In the development process of an educational application, there are also other people involved besides educational experts. This paper describes a project which primarily aims at developing an application for the needs of enhancing perioperative nursing skills'.

Besides application development, the project included research about the process. The research task was to discover how the real – not only the formal – objectives could work as the starting point for the construction of an educational game-like application. This paper presents the study process based on the panel discussions of nursing teachers. In the panels, the teachers elaborated the objectives. The transcribed discussions were analysed in terms of conceptions of learning and teaching of perioperative nursing.

The outcomes, the elaborated objectives, were aimed to be used as a basis for the implementation of an educational game. In addition, the discussions were analysed from the perspective of the learning paradigm they reflected. It is argued that views of learning are necessary to be understood in order to make appropriate choices of educational strategy throughout the development process. Finally, this paper presents initial observations of a user study of the game. They are discussed from the point of view of project success and the potential of the chosen approach. It is concluded that the construction of this kind of game is a much more effective means of learning than the playing of it, thus suggesting that students themselves should be used as authors.

1 INTRODUCTION

The purpose of constructing an educational application is – or at least should be – to promote learning. Therefore, learning objectives should be the primary criteria in all stages of the development. However, it is far from clear regarding what the objectives are when educating perioperative nurses. We know that perioperative nurses' work in operating department and their role at the hospital is to provide care to the patients independently and responsibly together with other healthcare professionals. These nurses provide care and support to patients before, during, and after surgery (pre- intra- and post-operatively). Perioperative nurses' responsibilities prior and during surgery are, for example, instrument and sterile environment preparation and maintenance, and assisting surgeons during the operation (Mitchell and Flin, 2008). Perioperative nursing skills include cognitive, social and technical components such as using various operating theatre (OT) equipment. Sometimes highly automatised technical skills are needed; sometimes fast reasoning and reaction should be applied to constantly changing treatment situations and a wide variety of different patients. Therefore decision-making skills, adaptability to new situations, as well as competence in evaluating rapidly changing and challenging situations are important. Also ethical considerations and problem solving is needed. Perioperative nurses are required to work in teams with other healthcare professionals, including multi-professional teams, thus group work skills are essential. Perioperative work environment is also stressful and often physically straining, which should be taken into account in their education.

Patient safety and patient care are core elements of perioperative nursing. Nurse education is a central means to reduce or prevent noticeable risks and errors in perioperative work (McConnell and

Hillbig, 2000; Pirhonen and Silvennoinen, 2011). All these requirements should be acknowledged when designing and implementing new ways to train perioperative nurses. Suitable means for responding to these requirements should be explored.

There are studies presenting the perioperative nurse's skills and requirements in the forms of required competences which should be developed through clinical learning activities such as knowledge, skills and values. These are presented in Table I (AORN, 2007).

Table 1: Perioperative Nurse's Competencies.

Knowledge	Applying knowledge on anatomy, physiology, and pathophysiology to understand the procedure, its effects on the patient and patient needs
	Recognising ethical and legal responsibilities, the nurse's accountability to the patient, the profession of nursing and team work
	Applying research findings to planning and implementing effective perioperative care
Skills	Learning and refining aseptic techniques
	Improving patient assessment, communication, organisation, coordination, critical-thinking, and decision-making skills in an environment where such activities must be performed quickly and accurately
	Providing opportunities to assess own interest and talents
Values	Developing the role of advocate for the patient by identifying the patient's expressed and unexpressed needs
	Responding to those needs through the action of facilitating or mediating among all providers involved in the care process
	Recognising diverse career opportunities in perioperative settings
	Participating as a member of multi-professional health care team that develops and promotes the continuity of patient care in an environment that reinforces an understanding of a nurse's independent and interdependent function

Perioperative nurses' core competencies are critical-thinking and sound clinical judgment which should be used effectively to meet patient needs (Cafira and Janiszewski Goodin, 2011). Critical-thinking and clinical decision-making skills are essential components which are acquired in perioperative work. These can be learned for example with concept mapping which is a tool for efficiently perceiving relationships between concepts (Noonan, 2011). Critical-thinking and decision-making skills could also be learned with the help of educational games which foster collaboration and critical-thinking among peers and associates (Cafira and Janiszewski Goodin, 2011).

Due to the extremely diversified contents of perioperative nursing skills, it is relevant to consider the application of computers in this education. This paper discovers the potential of interactive technology in the education of perioperative nursing. The paper draws on an application development project, in which the authors participated particularly as experts of education.

In the current case study, the application of interactive technology was inspired by previous, successful application of computers in the teaching of nursing skills (Huff, 2003; Cafira and Janiszewski Goodin, 2011). In these studies, computer-based educational games, such as web-based courses including quizzes, examinations and reviews were applied and some learning benefits discovered. In the teaching of perioperative nursing, using games to teach, learn, and reinforce perioperative material through experiential techniques has potential in promoting critical-thinking (Sewchuk, 2005; Cafira and Janiszewski Goodin, 2011).

1.1 Related Project

The current study is based on an assignment, in which a prototype of an educational game for the educational needs of perioperative nursing was supposed to be implemented. The development project group consisted of specialists from three large organisations. The teachers of nursing education (University of Applied Sciences), education and usability researchers (University) and nurses working in the field (hospital), as well as other IT and management professionals. In addition, there was a project leader and responsible leaders of each participating organisation. The main realiser of the game construction was an independent IT software company which was selected based on an open bidding competition.

2 THE ORGANISATION OF THE STUDY

The organisation of teaching is a complicated process in which learning is the primary objective. Typically, the role of an individual teacher is central – his or her conception about what learning is and how it could be promoted. Also, the teacher's view of the curriculum is obviously pivotal in terms of what content is important and what is not. The conclusion is obvious: more important than what is told in the formal curricula is the teacher's interpretation or conception of the curricula.

In the current study, we combined the handling of curricula and learning conceptions in one single empirical setting. We first prepared a tentative set of learning objectives for perioperative nursing. By learning objectives we mean both the formal objectives which are written in curricula, as well as the objectives that the teacher is implementing, which arise from numerous sources, such as formal documents. In the current study, we seek the so-called 'hidden curriculum' as well. The tentative set of objectives was based on the formal objectives of the local school which educates nurses (JAMK University of Applied Sciences, see http://www.jamk.fi/). These tentative objectives were then elaborated by two expert panels, each of which consisted of three experienced nursing teachers from JAMK. The panels were moderated by a researcher, who recorded the discussions. In the panel sessions, the objectives were discussed in the order of objective categories. Each panel session took about 60 minutes. After the panel sessions, the objective table was finalised by the researcher.

The recordings of the discussions were transcribed. The transcriptions were analysed in terms of conceptions of learning. The expressions that the teachers used were classified according to the perspective of learning that they reflected; behaviourist, cognitivist, or constructivist. This set was then presented to two independent teacher panels, in order to discuss and elaborate the proposed objectives.

3 CASE STUDY: OBJECTIVES IN STUDYING PERIOPERATIVE NURSING

The tentative table of objectives was elaborated by two expert panels. The structure of the table follows the widely used categorisation: Knowledge, skills and attitudes, each of which is handled concerning theoretical, professional, social and ethical aspects. We now present the elaborated version of the objectives in four separate tables: theoretical (Table II), professional (Table III), social (Table IV), and ethical (Table V). The objectives in the tables should be read by starting each objective with "After studying perioperative nursing, the student…" The numbers in the parentheses at the end of each category in Tables 2-5 indicate the number of comments in the transcription.

Table 2: Theoretical Aspects.

Knowledge	Has acquired the core concepts of perioperative nursing to the level required for the construction of theoretical knowledge in the area. (13)
Skills	Utilises relevant literature in the area of expertise in order to construct knowledge. Is capable of critically assess references and is able to apply the constructed knowledge in an appropriate manner. (10)
Attitudes	Is interested in nursing practices and science related issues in diverse contexts. Understands the significance of continual construction of new knowledge in the development of him/herself and his/her expertise, as well as in the securing and promoting of the function of his/her group and the whole organisation. (1)

Table 3: Professional Aspects.

Knowledge	Is aware of his/her professional strengths and recognises areas which require further development. (31)
Skills	Is able to work by applying the approaches, methods and principles of perioperative nursing, in terms of his/her own role, in a patient-centric manner, taking care of patient safety. Applies his/her professional skills and knowledge, such as clinical skills, medication, infection prevention, pain treatment and decision-making skills in an appropriate way. Detects problems and uses creative problem-solving in decision-making. High pressure tolerance. Monitors, assesses and reflects his/her own work critically. Promotes mental and physical well-being in work and occupational health and safety through his/her own activity. (27)
Attitudes	Is willing to learn new things in the domain of nursing. Understands the importance of his/her expertise from the point-of-view of the work community and society as a whole, and is proud of it. Understands his/her own personal responsibility as an expert of nursing. (24)

Table 4: Social Aspects.

Knowledge	Conceptualises nursing as human-centred and, in particular, patient-centred work, in which social interaction plays a central role. Understands the aspects of group forming and functioning. (6)
Skills	Is able to work all-round and interact as a member of diverse groups. Is able to work in different kinds of patient related situations in an interactive manner, taking the individuality of a patient into account. Is capable of contributing constructively to the forming of a group, as well as to the achieving the of objectives of the group. Is able to act according to his/her own role in the group work context. Is able to utilise and provide feedback. Recognises phenomena relating to group dynamics, and reacts to them appropriately (context sensitivity). (20)
Attitudes	Understands his/her personal role as a member of a group and the significance of working together in order to achieve the common objectives. Understands his/her role from the patient's perspective. Accepts differing viewpoints. (7)

Table 5: Ethical Aspects.

Knowledge	Is aware of the ethical issues and perspectives of nursing. Knows the commonly agreed and contradictory values related to nursing. Understands the challenges and opportunities of multicultural settings from the point-of-view of own work community. (6)
Skills	Recognises and is able to analyse ethical issues of nursing, and is able to solve and apply them appropriately. Follows the widely accepted ethical principles of nursing. Is able to assess his/her own work against ethical criteria. Dares to tackle detected flaws and solve them constructively. (3)
Attitudes	Considers ethical issues pivotal for nursing. Is willing to promote community discussion about ethical issues through his/her part in his/her work. Interprets the treatment of patients, colleagues and other members of the work community primarily as an ethical issue. (1)

As can be seen, professional knowledge, skills and attitudes clearly evoked the most discussion. It appears that attitudes other than purely professional ones did not get much attention. On the basis of our data it is difficult to say whether this indicates lower prioritisation or whether it is simply an area that is more difficult to verbalise, and in turn difficult to discuss. Ethical issues induced surprisingly little discussion – again, the reason is difficult to see on the basis of the current data.

4 FORMULATING INTERACTIVE APPLICATION OBJECTIVES FOR LEARNING PERIOPERATIVE NURSING

The central education research aim in this project was to produce knowledge and test how the real – not only the formal – objectives could work as the starting point for the construction of an educational game. Applying these discovered objectives into the game development was the subsequent goal after this study. The game development had already begun before the research results were finished. However, the purpose to form a basis for an educational application based on these learning objectives still seemed possible, because no actual content of the game had been build. Some central decisions, such as programming language and platform of the game had already been decided within the leading organisation, based on the recommendations of the software company. The university researchers in this game development project operated as consultants making suggestions and recommendations based on the study. These recommendations for the game execution were presented in the project group meetings. For example, the learning objective tables were suggested to be used while combining the content of the game such as tasks for the students to solve during playing. Also, content examples were offered to the content providers (specialists in nursing science). The most important recommendation was that the objectives of perioperative nursing education should be the basis of the whole application. Or if the application would only cover a portion of the educational objectives, the minimum requirement would be that the application is not in contradiction with the objectives. In other words, it is overly ambitious to aim at covering the whole content of education with one single application. Yet, still it should follow the principles that the over-all objectives indicate.

When we first prepared a tentative set of objectives on the basis of the formal curriculum and then elaborated it with the teachers, we found that teachers' conceptions were well in line with the formal objectives. In other words, this study did not reveal a dominant hidden curriculum, but the formal curriculum has been developed in parallel with practical needs, thus making a lot of sense for the teachers. While the discussions concerned the existing learning objectives, it can be concluded that the teachers think that perioperative nurses need several sorts of skills, ranging from highly automatised routines to the ability to act creatively when necessary.

When we reflected on the objectives in light of the strengths of educational games, it became evident that only certain kinds of objectives can be covered with a game, no matter how sophisticated it may be technically or pedagogically. The widely acknowledged strength of an educational game is that it is a motivating means to train skills which require a large amount of repetition. As discussed above, perioperative nursing includes these kinds of skills which are typically highly automatised routines. At least in the training of these routines, games have potential. From the point-of-view of the application to be designed, this would mean that all the objectives of perioperative nursing education are not appropriate for inclusion into the pedagogical requirements of the forthcoming application.

5 APPLYING THE LEARNING OBJECTIVES

During the game development, the nursing teachers and student groups were acting as the main content providers. This task however proved very challenging, in spite of the previously defined learning aims. The content providing was heavily restricted by the technological limitations of the software. As a result, only certain types of computer assisted learning could be implemented, such as multiple choice questions. In order to cover all the aspects of the perioperative nursing skills addressed earlier, this is obviously not adequate. Formulating the questions which address, for example, ethical attitudes and the learner's inner state of mind could be rather complicated to put into practice this way. Even though the game technology also afforded open questions, the analysis of the success or failure of the learner's answers became impossible. Therefore, the questions applied in the game prototype covered almost solely professional skills and theoretical knowledge. This gave the game a certain form of written examination with multiple choice questions, even though videos and pictures were added to provide variation.

There are several risks for the success of learning with this kind of game. It is overly ambitious to assume that the players would maintain a high level of motivation after playing a few times. The questions measuring only superficial learning or memory are hardly challenging. The problem-solving tasks which require applying own reasoning and reflection and which do not necessarily have only one right or wrong answer would be much more practical within this learning context. Game-type learning always requires some kind of measurement of success or failure. It should also include some form of competition in order to be motivating and addictive for the player. It can be stated that the objectives of perioperative nursing skills learning are hardly always issues which can be used in a competitive form or measure at all. Sometimes this issue and the issue of game playing could even be in contradiction to one another.

The success of the project can be measured by varying criteria. A suitable one in this developmental project context is the result and product success. The different stakeholders, e.g. contractors, sponsors, project managers, team members, users, ICT developers etc. might see the project goals as well as the product success in a number of ways (Pirhonen, 2013). According to Pirhonen (2013), product success is a longitudinal measurement which can be assessed according to several criteria: whether it meets the organisational strategic objectives, how satisfying it is for users and stakeholder needs, what the business success is and what the financial rewards are. These can be completely verified once the product, in this case an educational game, has been utilised. The result from the various viewpoints can be that the objectives of the game development project are not solely the same as the objectives of the education research aiming at maximal skills and learning objective attainment. Sometimes the game development project is guided by a strict budget and objectives to develop visibly measurable results for the financing organisation as fast and efficiently as possible. The consequences of the differing aims and viewpoints should however be acknowledged and understood while evaluating both the product and the entire success of the project. In this project, the development of a prototype of an educational game was in many ways successful and the quantitative requirements were fulfilled. Yet, the acknowledged shortcomings relating to learning content were clearly an issue to address when the follow-up project was launched at the beginning of 2014.

One definite conclusion is that at the beginning of the project, the technical implementation of the application was seen as the major challenge. Having recently conducted a concise user study with six students, we argue, however, that the real challenge is in the authoring of the content, not the technical issues. The application itself mainly supports low level learning. The construction of the content, on the contrary, may be much more demanding. If the students of nursing are contributing to the content of the game, this authoring process may be a much more rewarding learning process than the actual playing of the game. In other words, the authoring of the relatively primitive game works as a framework or excuse for an activity, during which higher order thinking skills are applied.

In the near future we will analyse the work of student groups: How they generate game ideas and how the application supports the implementation of the ideas.

ACKNOWLEDGEMENTS

The work is funded by European Social Fund (ESF) in Finland.

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The Impact of Proper Use of Learning System on Students' Performance
Case Study of Using MyMathLab

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Keywords: Independent Learners, E-learning, Learning Management System, MyMathLab, Study Plan.

Abstract: In Summer 2012, the Foundation Program Unit of Qatar University has started implementing new ways of teaching Math by introducing MML (MyMathLab) as an innovative interactive tool to support standard teaching. MML is used to enhance learning and motivate students to be engaged outside the classroom in the learning process. In this paper, we focused on the effect of proper use of one of the component of MML the Study Plan on students performance. Authors investigated the results of students in Pre-calculus course during Fall 2012 in Foundation Program and in Business Mathematics during Spring 2013 at Qatar University. The results showed that there was a strong correlation between students' results in study plan and final course grade results in Pre-Calculus course and how Business Math students benefited in using Study plan in MML to improve their Math skills. Also in this paper, we included the survey's results on the use of MML.

1 INTRODUCTION

In this decade, the traditional ways of teaching have almost disappeared. In many fields of life, there is a huge evidence demonstrating that technology-enhanced instruction will definitely improve the student learning outcomes. It will also utilize the resources available to instructors and educational stakeholders. Jostenś Learning Corp and the American Association of School Administrators conducted a study of 1,0000 teachers and found out that 94% of instructors and school superintendents believe computers have improved teaching and learning (Law et al., ; Tapscott, 2005).

It is also revealed that the use of technology in education expands course offerings and learning materials in addition to increasing student engagement and motivation. Moreover, it will support learning 24 hours a day, 7 days a week.

In our study, we highlight a tool called MyMathLab (MML) which is an online interactive and educational system. It covers courses from basic math through calculus and statistics, as well as math for business and future educators. It is designed mainly for learners who seek more opportunity for practice, immediate feedback, and automated grading. It was developed by Pearson, a textbook publishing company. It is claimed by the company that since it was released, it has been used by 9 million students at 1,900 colleges in the United States. According to a Pearson survey, 80% of students who used this tool have reported that MML has helped them to succeed(Speckler, 2010).

Section 2 includes a literature review of some e-learning systems. Section 3 mainly focuses on the Study Plan component of MyMathLab. Section 4 discusses the results and finding of the study. Conclusions and recommendations are presented in Section 5.

2 LITERATURE REVIEW

Many studies were done in the field of integrating technology with Math learning and teaching. In 2001, Souters research study observed five algebra classes involving four teachers and 92 ninth-grade students. He concluded that using integrating technology into mathematics can increase student achievement and motivation which will lead to enhancing students overall performance(Raines and Clark, 2011).

Moreover, some studies have approved that when the student uses graphical calculator during their learning process, then it makes it easier to decide the best technique to solve the questions which will lead to better learning outcomes. Several other research studies have inspected the impact of technology on student learning and found its use is associated with skill development, content mastery, and increased exam scores(Strayhorn, 2006; Hofmann, 2002).

One of the well known tools that aims at self-regulatory skills during learning about complex and challenging topics when using open-ended learning environments is hypermedia(Azevedo, 2005). The advantage the MML has over this tool is the auto-generated questions by the study plan in the areas the student face difficulties with.

Furthermore, the use of technology will make it easier for the instructor to use the e-assessment tools. This will enable faster decision making in the matter of tracking students levels and skills, with greater validity, and a lower cost compared to the traditional assessment procedure.

3 MYMATHLAB:'STUDY PLAN'

In Summer 2012, the Foundation Program Unit of Qatar University has started implementing new ways of teaching Math by introducing MML as an innovative interactive tool to support standard teaching. Our main focus in this study is the 'Study Plan' component of MML. Study Plan is designed for students to improve their skills wherever they face difficulties with in homework, Quiz or Test. After completing each assigned question, Study Plan will generate questions that focus on each learning objective that the student have struggled with.

We have focused on two groups of students, those enrolled in Pre-Calculus course and those who are enrolled in Business Mathematics course. In Pre-Calcluse for Fall 2012, the total number of students enrolled was 179 female student and 107 male students, as shown in Table 1. The average number of hours that the students engaged outside the classroom was 18.77 hours for female students and 12.09 hours for male students.

For Business Mathematics students, MML was piloted by one female and one male group. The number of students involved in this piloting were 41 female students and 31 male students. In this study, students performance who used MML was compared to those who did not use MML of total 241 female and 65 male students.

Table 1: Total Hours Spent on Study Plan - Pre-Calculus.

Factor	Female	Male
Max	116.75	73.87
Min	0.0	0.0
Median	13.03	7.93
Average	18.77	12.09
Std. Deviation	19.34	13.29
Total	3359.84	1293.62
Students Enrolled	179	107

4 RESULTS AND DISCUSSIONS

4.1 Pre-Calculus Students Results

In our study we used the coefficient of correlation r to determine whether the is a correlation between effective use of the study plan and students' performance for Fall 2012 students. We computed **r = 0.94** which indicated that there was there was a strong correlations between completing the required questions in the study plan and a good student's performance in the course.

Similar study was conducted in summer 2012 for a smaller sample and we found **r = 0.92** which confirmed the beneficially of the effective use of the Study Plan on learners. The relation between the percentage of completing the required Study Plan and the students' overall grades is shown in Figure 1.

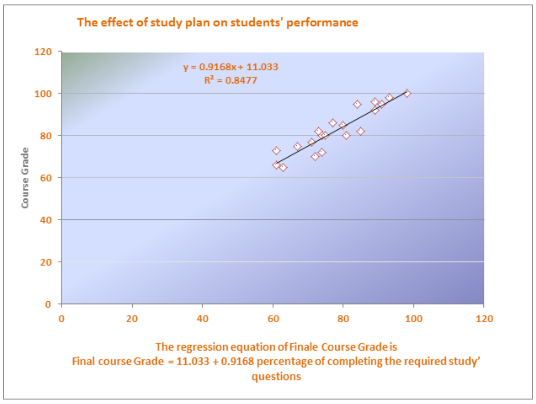

Figure 1: The effect of study plan on performance of students

4.2 Business Mathematics Students Results

Since we do not have mixed classes at Qatar University, the study was carried out on separate groups of female and male students. MML was not used from the beginning of the semester for Business Mathematics students. It was heavily used after Quiz4 and

Test1 and Figure 2 shows the effect MML on students progress. From the chart, there was an improvement for student performance after Quiz4 through the final exam. For the intermediate tests, the students grades have improved from 55% in Test1 (without using MML) to 75% in Test2 after using MML.

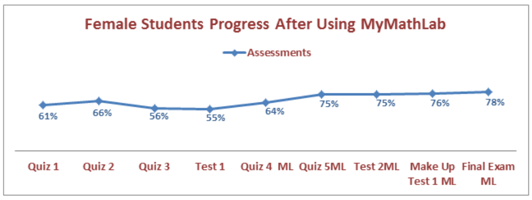

Figure 2: Female Students Progress After Using MML in Business Math Course.

Figure 3 compares the grades of students who used MML versus those who did not. It was clear that those who used the tool scored higher than those who did not. 18% of students who used the tool got an 'A' while only 4% of those who did not use MML got an 'A'. The failure rate for those who did not use MML was much higher than those who did use it, 31% versus 60%.

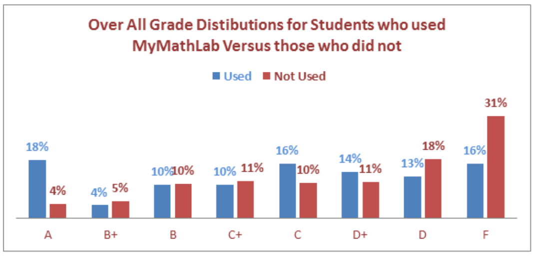

Figure 3: Students Grades in Business Math Course.

Figures 4 and 5 show the distribution of female and male students who used MML with those who did not. Among the results we got, the failure rate for female students who did not use MML was 30% versus only 12% for those who used it. Also, for male students, the percentages for students who got an 'A' for those who used and those who did not were 26% and 0%, respectively.

Figure 6 shows the pass and fail rates of students versus those who used MML with those who did not. 84% of those who used MML passed the course while only 69% of those who did not used it passed the course.

4.3 Students Feedback

A survey was conducted for students who used the MML. In the survey, we included several questions regarding the use of MML. In this paper, we focus

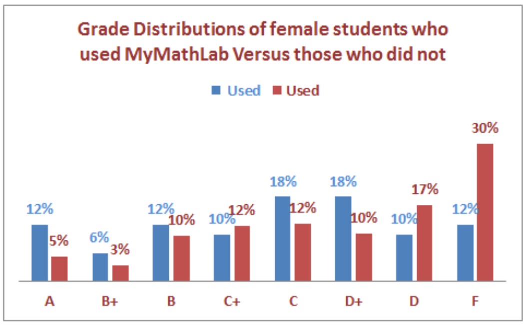

Figure 4: Grades Distribution of Female Students Used and Did Not Use MML in Business Math Course.

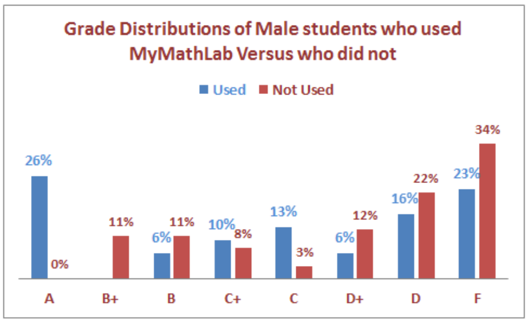

Figure 5: Grades Distribution of Male Students Used and Did Not Use MML in Business Math Course.

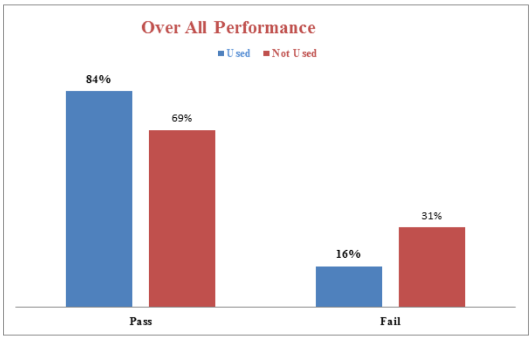

Figure 6: Students Overall Performance in Business Math Course.

only on two aspects: The first question, whether or not the students were satisfied with the use of MML and the second question was how much the Study Plan component of MML had helped students to improve their math skills.

The survey showed for question one, 87% claimed that they were very satisfied while only 13% said they were not satisfied with the MML.

The second question showed that 92% of students who took the survey found Study Plan Component was very useful for them versus 8% found that Study Plan was not helpful during their learning process. The survey results are showing in the Figures 7 and 8 respectively.

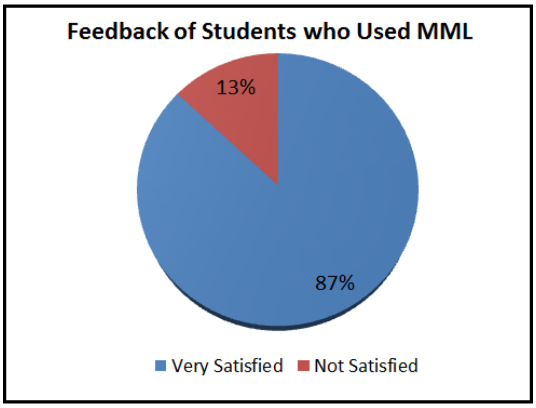

Figure 7: Students Feedback about MML.

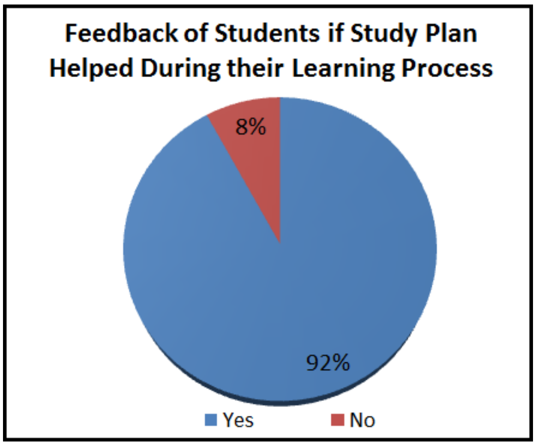

Figure 8: Students Feedback about Study Plan.

5 CONCLUSIONS

Our study showed that there was a very strong positive correlation between completing the required questions in the study plan and students final course grade in the Pre-Calculus course also the effect of the use of study plan on Business Math students in improving their performance. Consequently, Study Plan helped students to improve their math skill and it is the key component of MML. We believe that more time the student spend in Study Plan and Homework, the higher chance he or she will pass the course with higher grade. Based on students results we recommend the following:

- All instructors should emphasize to their students the importance of use of Study Plan and its effect on their performance.
- Continuing monitoring students performance in study plan to alter those who are scoring poorly in the study plan for early intervention.
- Use study Plan results as early indicators of students at risk.
- In assessment method we should put more weight in study plan by increasing it by 5% at least.
- Repeat the conduct similar study for Fall 2013 as well as Spring 2014.

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Developing Open Source Dataloggers for Inquiry Learning

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Keywords: Dataloggers, Arduino, Open Source, Inquiry Learning, Project-based Learning, Hands-on Assignments.

Abstract: There exists a continuous need to promote better Science Technology Engineering and Mathematics (STEM) education at the younger students. To satisfy this need hands-on laboratory assignments and inquiry learning projects are widely accepted as appropriate approaches. One key issue for both approaches is the effective and adaptive data logging. This article describes the development of educational datalogger devices, using open source software and hardware which can be used to collect, present and save data for both offline and online analysis. The novelty of the proposed devices lies on the fact the presented implementations are not dedicated devices bind to specific features but they can be seen as educational datalogger platforms which are expandable and adaptive to students' needs in a minimum cost since they are based in open source solutions.

1 INTRODUCTION

The systematic displeasure with science, technology, engineering and mathematics (STEM) among young people (McCormarck, 2010) is a challenging problem that remains unsolved. Its solution is not necessary only because today students are potential tomorrow scientists but also because we demand from them to be critical reviewers of scientific knowledge : "*improving the public's ability to engage with such socio-scientific issues requires, therefore, not only a knowledge of the content of science but also a knowledge of 'how science works'*" (Osborne and Dillon, 2008). Recent studies (European Commission, Science education now, 2007) present a lack of interest among young people towards scientific topics which leads to declining number of university graduates in STEM areas. This is reflected as a shortage of scientists and engineers in the job market which comes in contrast with the prediction that there will be significant needs for medium and high-skilled jobs as pointed out by several studies [US Dept. of Commerce (2011) indicates 17% grow from 2008 to 2018, compared to 9.8% growth in non-STEM fields; European Table of Industrialists (2009) estimates 50 million new STEM jobs by year 2020)]. It is more than obvious that adequacy in STEM can serve as a major keystone in developing adequate Research & Development capacity leading in this way to competitive innovators that will possibly lead the technology market far more competitive than in previous years.

A critical determinant on the above is an education approach that will be able to enable young people's corresponding key abilities (e.g. the ability to learn how to learn, developing mathematical, scientific and technological skills, being creative and active citizens). Students must be exposed to this type of education very early in order to spark their interest and ensure they received all the required supplies leading towards to a valued university degree in STEM areas. There is no doubt that teachers, schools and the education system at whole have the responsibility to cultivate a positive attitude to science to young people (Gras-Velázquez et. al., 2009). Their motivation is of major importance in order to decide studies in STEM areas. Schoolchildren's views of science are formed usually at primary school level and these views are highly committed to their attitudes to science and technology (Osborn and Dillon, 2008). As Gipps (2002) pointed out "*Scientific inquiry cannot be made independent of the context, observer or means of observation, and its successful prosecution will usually require creativity and intuition, qualities that* *do not appear on standard diagrams of 'scientific method'"*. Science oriented project provides the students the outline of the thinking and planning skills required by professional scientists (Hodson, 1998). Under this approach students can get some idea of the people who sometimes guess, often try things without knowing what the exact result will be and it is not rare that many experiments "fail". Shapiro (1996) asserts that the lack of investigation results that the majority of students completed their secondary programs having missed involvement in developing an understanding of the very nature of science itself.

Data logging lends itself particularly well to scientific inquiry and may be the best educational use that can be benefited of this technology (Gipps, 2001). Data logging methods allow pupils to assume more responsibility and control in their science practical investigations. The instant display of measurements allows students to set new hypotheses and change conditions to carry out further experiments. Graph generation soon enough after making a prediction greatly facilitates the pedagogical technique of *'Predict-Observe-Explain'* (Osborne and Hennessy, 2003) with rapid feedback and the possibility of sorting out of the reasons for unsuccessful predictions. Students were able to 'feel' for how the action and sensing reaction are related and can therefore have a better understanding of the meaning of the graph. Instant data logging and analysis are strong motivating factors for students to collect multiple data through repeated measurements. Thus, this combined (logging and analysis) process enables students to experience the entire inquiry process as holistic and cyclical (Rogers and Wild, 1994) a scenario that is rare in a conventional science practical lessons.

The purpose of the current paper is to demonstrate the design and implementation of three low cost educational dataloggers based on Arduino open source prototyping platform suitable for carrying out the scientific inquiry learning outcomes. The obvious purpose of our efforts is the minimization of the cost (comparing to corresponding solutions) along with the provided flexibility (e.g. open source firmwares for different measurement scenarios, unrestricted changes through Arduino or Visual programming environment) as well as with easiness to use (e.g plug & play sensors, wizard type questions, touch screen for user input, ready to run experiments).

2 DESIGN CONSIDERATIONS FOR AN EDUCATIONAL DATALOGGER

A modern educational datalogger must be capable of providing some advantages over its predecessors. Some of them can be the deconstruction of traditional boundaries between distinct learning environments, the strong search capabilities, the interaction ability as well as the effective learning and familiarization with state-of-the-art technologies. These advantages lead to some basic design requirements as below (Hloupis et. al, 2012):

- Ease of use: Students without computer experience must be able to use it (e.g. use of phone-like touch screens).
- Adaptability: student's needs and skill must define system's boundaries (e.g. no need for excessive training in order to use the datalogger)
- Suitability: Subjects must provided with various ways of gathering the learning outcome (e.g. a solar energy experiment must be carried out by means of different sensors)
- Availability: operations and functions must be available using simple procedures (e.g. adding a new set of sensors must be a common procedure independent from sensors' type)
- Usefulness: actions and dissemination must be in familiar forms (e.g. data transfer by means of SD cards of USB drives, data processing with ready-to-run software)
- Open source and low cost (e.g. users must be able to select the desirable features and characteristics from a range of cost effective options)

The above design requirements can be weighted proportionally leading to implementation solutions that will be different in their final form. In the current study the prototypes of three representative solutions are demonstrated where briefly described at Table 1.

The selection of Arduino platform as the core of the proposed educational dataloggers dictated from two additional factors (except the fulfilment of design requirements that stated earlier): its open source characteristics and the huge amount of support that can be found in Internet today. For readers that are not familiar with Arduino platform excellent introductory material can be found in official site (www.arduino.cc) as well as in several textbooks (Banzi, 2011; McRoberts, 2010; Oxer and Blemmigs, 2009; Noble , 2012).

Table 1: Features of proposed educational dataloggers.

Short name	Common Features	Main (additional) Features	Firmware / hardware provided	Final Cost
Medimnos	• Plug & Play, colour coded external sensors • Real time clock (RTC) • Data capturing interval selected by the user. • Data storage on an SD card for offline analysis. • Battery operated.	✓ LCD character screen ✓ Push button control ✓ 8 Analog inputs	YES (Arduino codes & Schematics)	~20€
Kyathos		✓ 1.8" 18-bit Color TFT ✓ Joystick control ✓ 16 Analog inputs ✓ Data sent over the USB for online analysis.	YES (Arduino codes & Schematics)	~40€
Kotyli		✓ Touch screen with custom designed interfaces (software provided) ✓ Predefined experiment templates ✓ 16 Analog inputs ✓ Data sent over the USB for online analysis.	YES (Arduino codes, Interface Graphics & Schematics)	<100€

3 EDUCATIONAL DATALOGGER PROTOTYPES

3.1 Common Features

Since the prototype dataloggers share some common features, these will be explained in detail initially.

- Plug & Play external sensors. Ease of use can be highly benefited if we release users from obligatory sensor selection. Keeping in mind that the proposed dataloggers can be used even in primary schools curricula we propose a colour code scheme for sensor signalling. Under this approach the students only have to match the colour of sensor outlet to corresponding coloured input of the datalogger. A quick visual check by the teacher can ensure the validity of the connection increasing at the same time students' confidence.
- Analog inputs. The low cost Arduino versions that based on AVR MEGA 328 microcontroller can provide 6 (Uno, Leonardo, Diecimilla, Pro, Lillypad) or 8 (ProMini, Nano, Fio) analog inputs. From them only 4 remain free for user input. To overcome this limitation we use only one analog input coupled with an 8x1 or 16x1 multiplexer and leave the remaining three reserved for future purposes.
- Real time clock. All measurements are time tagged by means of onboard RTC in `YYYY/MM/DD HH:MM:SS` format. The RTC is connected to its own battery so that the date and time information are not lost when main power is removed from the datalogger. Time data appended to analog inputs values providing a unique text string for each measurement
- Data capturing interval selected by the user. It is not expected that the students (especially the younger ones) will be familiar with terms like "refresh rate", "frequency", "period", "time interval" e.t.c. To overcome this shortage before every new measurement cycle we prompt a message to the user asking "how many times per hour" and waiting for the user input (using Up/Down keys). Under this approach teachers can easily explain more practically how the measurement sequence evolves (i.e. the number 6 means that the datalogger is going to measure every 10min). The hour basis was selected as a compromise between rapid measurements (e.g. sound, luminosity) and slower ones (e.g. temperature, humidity). Since the system is open source, in the provided software code, the teacher can easily change the capturing interval (i.e. by setting it in a per minute basis) as well as the prompt message.
- Data storage. The use of SD card except its obvious function of saving data offers two alternative impacts on hands-on approach: On one hand it provides an excellent springboard to the teacher in order to demonstrate (i.e. through educational gaming: "Spies and Secret Agents" where the precious SD cards hold the important

data) to students the difference between the instrument (e.g. the “system that measures”) and the results (e.g. the “data”). On the other hand the datalogger is capable for field measurement installations where the students can exchange the SD cards in predefined times (e.g. Weekly outdoor temperature measurements with SD card switching every morning in order to examine previous day’s measurements).

- Battery operated. The datalogger is powered from a 9V rechargeable battery. This is not mandatory since the datalogger designed in such a way that can accept power with minimum at 7V and maximum at 15V in any kind of popular formats (NiCd, NiMH e.t.c). There is also provision for the use of photovoltaic cells as power module providing in this way easy, long term, installations for field measurements.

3.2 *Medimnos* Prototype

This is the prototype that implemented using cost minimization as major design consideration .The modular view of this datalogger is shown on Fig.1. The main components of this prototype is a “barebone” Arduino board, a SD Card module, a RTC module, a voltage regulator, a 8X1 input multiplexer and monochrome LCD screen (Fig.2)

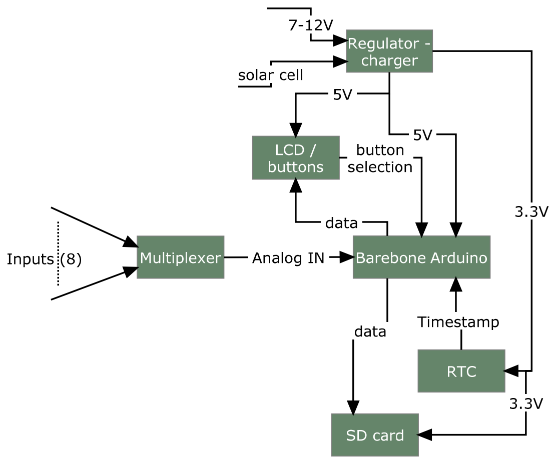

Figure 1: Modular view of Medimnos datalogger.

The sequence of actions for the student is straightforward (italics in parentheses are explanations of user actions) as below:

i) Startup (*Toggle On/Off switch – Welcome message appears*)

ii) Measurement quantity selection (*using Up/Down buttons*).

iii) Define measurement repetition (*response to question “how many times per hour” by means using Up/Down buttons*)

iv) Selection of concurrent measurement (*response to question “Add measurement ?” by means using Up/Down buttons*). “Yes” means return to Step *ii)* while “No” means go to next Step

v) Start Measurement (*user prompted with a message “Ready? Press Start” in order to start measurement sequence)*

Termination of measurements is achieved by pressing “Stop” button.

Data recorded in SD card as text files. Their names are in format `dataYYYYMMDDHHMMSS.txt`, where the values derived from the timestamp of 1st measurement. Every new measurement creates a new file. Inside the text file data are appended in tabular format with one header row, as below:

Date	Time	Temp	Humidity	Sound
2013/12/14	18:39:45	23.5	45	40
2013/12/14	18:41:45	23.4	45	52
2013/12/14	18:43:45	23.4	46	61

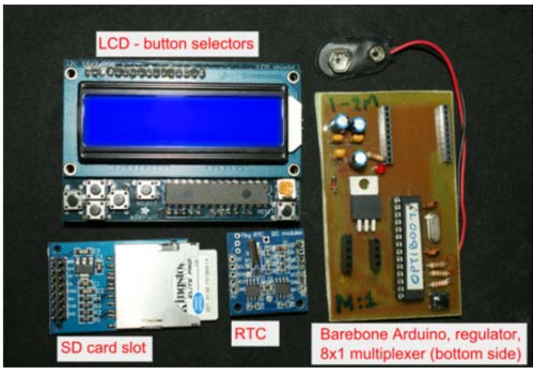

Figure 2: The main components of Medimnos prototype.

The tabulated format allows rapid import to all post-processing software (e.g. MS-Excel, OpenOffice e.t.c).

As long as the datalogger measures, the values of all the measuring quantities (i.e per analog input) displayed on LCD screen. The refresh rate of display is the same with measurement’s rate if this is not smaller than 30secs. If this is not happens (i.e. in frequent measurements) then the displayed value is the average value for the last 30secs of the measurement. This is done fully automatically and after the 30secs interval the current (or the averaged) value of the next measurement quantity is displayed. Under this approach every value is displayed for 30secs and if all the 16 analog inputs will be used 8mins required. Anytime the user can push the *Left/Right* buttons in order to see the value of *Previous/Next* measuring quantity without waiting

30secs for automatic switching.

3.3 *Kyathos* Prototype

This prototype uses an Arduino UNO board, a SD Card module, a RTC module, a voltage regulator, a 16X1 input multiplexer and a 1.8" color TFT screen with resolution 160x120 pixels with joystick selector. The Kyathos prototype can provide the values of all the measuring channels at the same time in TFT screen and these values can be colour marked (i.e. if a specific threshold is exceeded the presented value can be presented with red color) as presented in Fig.3.

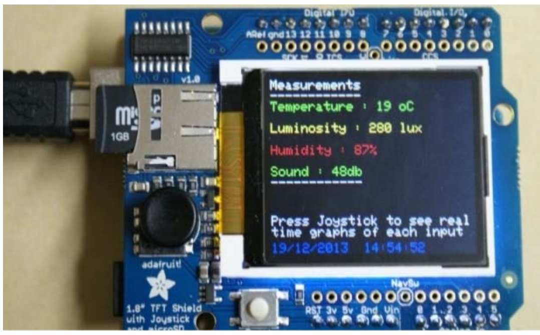

Figure 3: Acquired values' textual presentation screen for Kyathos prototype. Values are color coded (Red: over upper limit; Yellow: below lower limit; Green: beyond limits) and time stamped (blue message at bottom).

In addition, student is able to see additional screen plots with real time graph (Fig.4) of each the measurement quantity gathering in this way a preliminary but rapid view of quantity's behaviour. Effective visualization therefore reveals the meaning of data at several levels of detail, initially from a broad overview to the fine structure after data processing. This approach was selected since psychologists and education researchers very early proved the vital role of visual imagery in the processing of information (Bishop, 1989; Del Grande, 1990; Dreyfus, 1991; Presmeg, 1986; 1992) while problem-solving models (Goldin, 1987; Lowrie and Hill, 1996; Pirie and Kieren, 1991; 1992) have emphasized the role that imagery plays in the processing of information.

Simultaneously with screen presentation data sent to USB port providing in this way a route to real time data visualization in PC. At this point the students were able to see real time display of their measurements.

A free for educational use software packages like Stampplot (www.stampplot.com) can recognize the data stream from USB port and present it in familiar

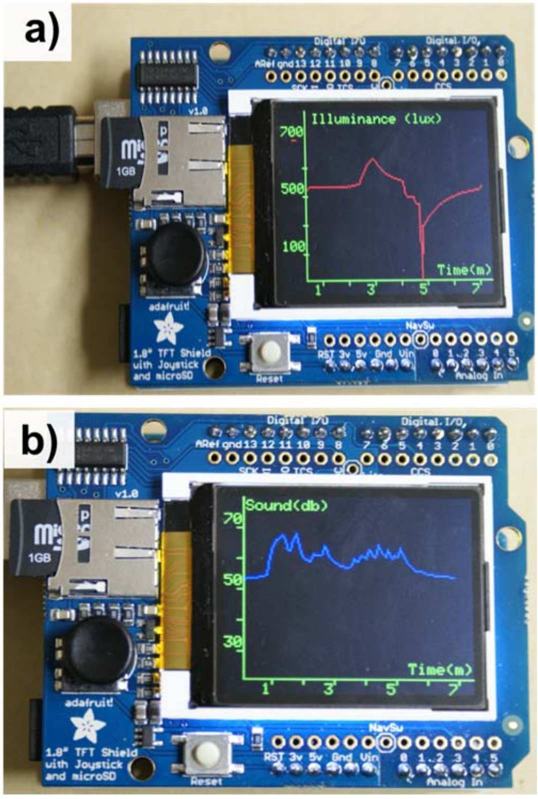

Figure 4: Real time graphs of measuring quantities from Kyathos prototype. Each graph hosts the values from one input (the measuring quantity signed on top left) while the student can subsequently transferred between graphs using joystick's left/right selections.

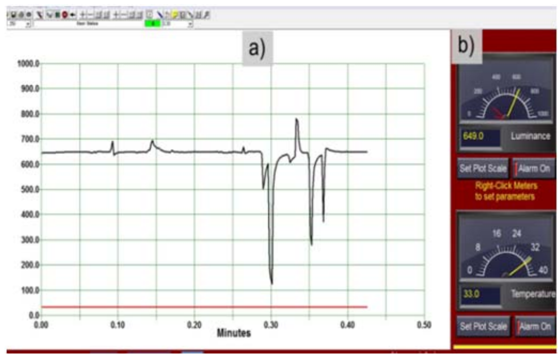

Figure 5: Real time presentation of acquired values that sent over USB in real time using Stampplot software: a) Data from channel 1 and b) data from channel 1 (top gauge) and channel 2 (bottom gauge).

ways to the students (i.e. like gauges or indicators) as presented in Fig.5.

Obviously the teachers are free to select any other alternative freeware solution (i.e LiveGraph, qSerialTerm, JGraph, Kst) since the data stream that is sent over USB is fully configurable in the provided Arduino codes. The remaining characteristics (SD card storage, sequence of measurement actions) remain the same as Medimnos except the use of joystick as selector instead of push buttons.

3.4 *Kotyli* Prototype

Mobile, handheld technology has become the leading trend of daily routine and the integration of touchscreen technology into mobile handheld devices is quickly becoming equally common. Based on this fact it is not unlikely to consider that students has become more familiar with touch screens rather than develop corresponding computer skills (i.e. keyboard input, mouse handling e.t.c.) for data input. Increasing usability and easiness led to the current prototype solution that is based on Medimnos prototype except that color TFT screen replaced with a 3.2” resistive touch screen. Resistive touch screens are pressure sensitive, so they can be operated with any input device, including a gloved hand or stylus. A solution like the above provide the flexibility to design custom graphics and user input interfaces thus increasing the adaptability of the datalogger to various hands-on projects (e.g. results of temperature measurements can be presented in a thermometer gauge). All the graphics can be designed in accompanying comprehensive software IDE for Microsoft Windows that provides an integrated software development platform for all. Buttons, labels, dials, gauges, input and backgrounds can be easily created using drag-n-drop actions Upon completion the user uploads the graphics and the relevant Arduino code is generated automatically.

An additional feature that added to Kotyli prototype is the use of predefined experiment templates. A set of common experiments (i.e. temperature measuring with one or two sensors, pH measurements, voltage measurements of common type batteries, solar activity during one day e.t.c.). To enhance the use of this feature a visual open source language for programming, Minibloq (http://blog.minibloq.org/) was selected in order to release teachers from configuring the Arduino using textual programming. Once installed, the program uses the usual drag-and-drop blocks editor style of working. The novel features are that there is simulation of the hardware and the code corresponding to the visual program can be seen in another window. Creation of new blocks is possible and this is the feature that used for uploading predefined experiments. Minibloq can be used also for any other procedure (i.e. uploading new datalogger firmware or design new experiment) as described in Medimnos and Kyathos prototypes. A representative screenshot form is presented in Fig.6.

Figure 6: Definition of new experiments using Minibloq visual programming language. The teacher selects predefined experiment blocks (from toolbar at bottom right) and drags them to the central panel. Possible configurations can be made by clicking graphical objects. Concurrently the corresponding Arduino code is presented at right panel while at the left panel a hardware view of Arduino connections is depicted.

Figure 7: Sequence of basic actions for Kotyli datalogger as presented in resistive touch screen: a) Selection of new or existing template for measurements, b) Selection list of available channels (in case of “New” measurement), c) Definition of measurement repetition (slider control), d) Prompting for sensor attachment and start measurement, e) Results in form of indicator f) Results in form of dial gauge.

The measurement sequence is slightly altered in relation with previous two dataloggers. Initially the

Table 2: Examples of inquiry based activities by means of proposed dataloggers.

Activities' aspect	***Level***	***Used sensors***
Sound proofing, Sound sources	Primary	Microphone
Light passing, reflection materials		Photoresistor
Sun as a source of heat & light		Photoresistor, Temperature
Insulation , Heat Energy		In / Out Temperature
Distance & Proximity measures		Sonar
Motion classification		Accelerometer
Energy Harvesting	Secondary	Voltage/current
Water quality		pH
Endothermic reactions		Temperature
Testing Sunglasses		UV photodetector
Crushing & Centripetal force, Tensile strength		Force
Environment & pollution		Gases - Dust
Weather prediction		Barometric – anemometer - humidity
Renewable resources (sun, water , wind)		Flow - Voltage - Solar - anemometer

student is asked if he wants a new or a predefined experiment. In case of predefined experiment button is pressed a list is loaded and the student just selects one from the list. In case of new experiment selection, a new screen asks the student to select the desired measuring quantity. The student selects by pressing the corresponding button and the next screen used for the definition of measurement repetition (question *"how many times per hour")*. After this, a message *"Add measurement?"* is appeared, providing the student the opportunity to append another quantity in measurement sequence. Next a screen appeared with a prompt message (in which port the sensor must be inserted) and a "Measure" button. Finally the results of the measurements presented as dials or gauges in real time. The whole sequence in screenshots is presented in Fig.7.

4 DIDACTIC UNIT EXAMPLES

The proposed experimental prototypes can be easily imported to STEM oriented class courses. Following an inquiry based approach students can experiment using their educational dataloggers as proposed in Table 2.

5 CONCLUSIONS

The design of an Arduino based portable datalogger devices has been described. The choice of Arduino as the core platform dictated from its suitability for starter projects, its cost and durability, a thriving community offering support and ideas and a maturity that is rare in open source solutions. Along with the programming easiness it seems that Arduino platform will prevail very shortly as the low cost solution even for educational projects. The three presented prototypes share some common features (Plug & Play colour coded external sensors Real time clock, Data capturing interval selected by the use, Data storage on an SD card for offline analysis, Battery operated) but each one has its own additional and unique features: *Medimnos* prototype implemented as low cost solution, *Kyathos* focus on real time presentations of results by sending data over USB and presented them at the same time in a color TFT screen (as independent values or as real time graphs) while *Kotyli* designed using the increasing usability and easiness as major determinants (using resistive touch screen and animated graphics for data presentation). Regarding *Kotyli,* the obvious comparison with Smartphones or Tablets, highlights its two main advantages against them: the fully configurable user interface (through open source solutions) and the sensors' plug-n-play capability (without using the USB port).

The intention of the authors is that the proposed implementations will act as starting points for adaptive designs to several curricula since the open source character of the designs ensures that this is an ongoing research. Along with the availability of Arduino codes it not overweening to claim that this open source platform will be accompanying the educational system for the next years.

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Graph Mining for Automatic Classification of Logical Proofs

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Keywords: Graph Mining, Frequent Subgraphs, Logic Proofs, Resolution, Classification, Educational Data Mining.

Abstract: We introduce graph mining for evaluation of logical proofs constructed by undergraduate students in the introductory course of logic. We start with description of the source data and their transformation into GraphML. As particular tasks may differ—students solve different tasks—we introduce a method for unification of resolution steps that enables to generate generalized frequent subgraphs. We then introduce a new system for graph mining that uses generalized frequent patterns as new attributes. We show that both overall accuracy and precision for incorrect resolution proofs overcome 97%. We also discuss a use of emergent patterns and three-class classification (correct/incorrect/unrecognised).

1 INTRODUCTION

Resolution in propositional logic is a simple method for building efficient provers and is frequently taught in university courses of logic. Although the structure of such proofs is quite simple, there is, up to our knowledge, no tool for automatic evaluation of student solutions. Main reason may lie in the fact that building a proof is in essence a constructive task. It means that not only the result—whether the set of clauses is contradictory or not—but rather the sequence of resolution steps is important for evaluation of correctness of a student solution.

If we aimed at error detection in a proof only, it would be sufficient to use some search method to find the erroneous resolution step. By this way we even would be capable to detect an error of particular kind, like resolution on two propositional letters. However, there are several drawbacks of this approach. First, detection of an error not necessary means that the solution was completely incorrect. Second, and more important, by search we can hardly discover patterns, or sequence of patterns, that are typical for wrong solutions. And third, for each kind of task – resolution proofs, tableaux proofs etc. – we would need to construct particular search queries. In opposite, the method described in this paper is usable, and hopefully useful, without a principal modification for any logical proof method for which a proof can be expressed by a tree.

In this paper we propose a method that employs graph mining (Cook and Holder, 2006) for classification of the proof as correct or incorrect. As the tasks—resolution proofs—differs, there is a need for unified description of this kind of proofs. For that reason we introduce generalized resolution schemata, so called generalized frequent subgraphs. Each subgraph of a resolution proof is then an instance of one generalized frequent subgraph. In Section 2 we introduce the source data and their transformation into GraphML (GraphML team, 2007). Section 3 discusses preliminary experiments with various graph mining algorithms. Based on these results, in Section 4 we first introduce a method for construction of generalized resolution graphs. Then we describe a system for graph mining that uses different kinds of generalized subgraphs as new attributes. We show that both overall accuracy and precision for incorrect resolution proofs overcome 97%. Discussion and conclusion are in Sections 5 and 6, respectively.

2 DATA AND DATA PRE-PROCESSING

The data set contained 393 different resolution proofs for propositional calculus, 71 incorrect solutions and 322 correct ones. Each student solved and handwrote one task. Two examples of solutions are shown in Fig. 1.

To transform the students proofs into an electronic version we used GraphML (GraphML team, 2007), which uses an XML-based syntax and supports wide range of graphs including directed, undirected, mixed

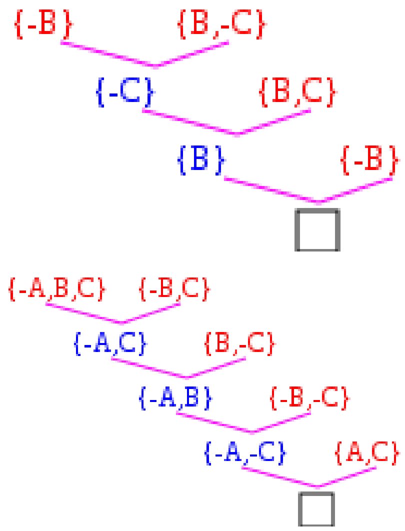

Figure 1: An example of a correct and an incorrect resolution proof.

graphs, hypergraphs, etc.

Common errors in proofs are the following: repetition of the same literal in the clause, resolving on two literals at the same time, incorrect resolution—the literal is missing in the resolved clause, resolving on the same literals (not on one positive and one negative), resolving within one clause, resolved literal is not removed, the clause is incorrectly copied, switching the order of literals in the clause, proof is not finished, resolving the clause and the negation of the second one (instead of the positive clause).

3 FINDING CHARACTERISTIC SUBGRAPH FOR RESOLUTION PROOFS

The first, preliminary, experiment—finding characteristic subgraphs for incorrect and correct resolution proofs—aimed at evaluating the capabilities of particular algorithms. They were performed on the whole set of data and then separately on the sets representing correct and incorrect proofs. The applications provided frequent subgraphs as their output for each set of data which help in identifying and distinguishing between subgraphs that are characteristic for correct and incorrect proofs, respectively. One such subgraph is depicted in Fig. 2.

Specifically, we performed several experiments with four algorithms (Brauner, 2013)—gSpan (Yan and Han, 2002), FFSM (Huan et al., 2003), Subdue (Ketkar et al., 2005), and SLEUTH (Zaki, 2005). With gSpan we performed experiments for different minimal relative frequencies ranging from 5 to 35 per cent. The overall running time varied from a few milliseconds to tens of milliseconds and the number of resulting subgraphs for all three data sets varied from hundreds to tens according to the frequency. Size of the output varied from hundreds to tens of kilobytes. With FFSM we tuned the parameters of our experiments so that the results were comparable to gSpan. Comparable numbers of resulting subgraphs were obtained in less time with FFSM. Despite the two-file output representation, the size of the output was slightly smaller in comparison to gSpan. With Subdue we performed several experiments for different parameter settings. The results were promising: we obtained from 60 to 80 interesting subgraphs in less than tenths of a second. The maximal size of output was 20 kilobytes. Unlike Subdue, SLEUTH finds all frequent patterns for a given minimum support.

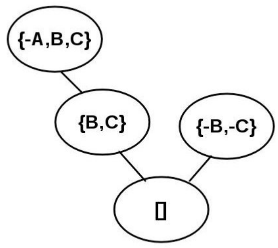

Figure 2: Characteristic subgraph for incorrect resolution proofs.

To sum up the examined methods for mining in general graphs, although all of them are acceptable for our purpose, Subdue and SLEUTH seemed to be the best. Subdue offers a suitable input format that is convenient for data classification. Readability of the output and, most of all, the relatively small number of relevant output graphs, makes Subdue preferable for finding frequent subgraphs in that type of data. A wide choice of settings is another advantage. In the case of SLEUTH, input trees, either ordered or unordered, can be considered. It is possible to search induced or embedded subtrees. The main advantage, when compared to Subdue, is that SLEUTH computes for a given minimum support a complete set of frequent subgraphs. For that reason we have chosen SLEUTH for the main experiment, i.e., for extracting frequent subgraphs and use those subgraphs as new boolean attributes for two tasks, classification of a resolution proof as correct or incorrect and classification of the main error in the solution, if it has been classified as wrong.

4 FREQUENT SUBGRAPHS FOR CLASSIFICATION

4.1 Description of the Method

The system consists of five agents (Zhang and Zhang, 2004; Kerber, 1995). For the purpose of building other systems for evaluation of graph tasks (like resolution proofs in different calculi, tableaux proofs etc.), all the agents have been designed to be as independent as possible.

The system is driven by parameters. The main ones are minimum accuracy and minimum precision for each class, minimum and maximum support, a specific kind of pattern to learn (all frequent or emerging (Dong and Li, 1999)) and minimum growth rate for emerging patterns.

Agent A1 serves for extraction of a specified knowledge from the XML description of the student solution. It sends that information to agent A2 for detection of frequent subgraphs and for building generalized subgraphs. A2 starts with the maximum support and learns a set of frequent subgraphs which subsequently sends as a result to two kinds of agents, A3 and A4i. Agent A3 serves for building a classifier that classifies the solution into two classes—CORRECT and INCORRECT. Agents A4i, one for each kind of error, are intended for learning the rules for detection of the particular error.

In the step of evaluation of a student result there are two possible situations. In the case that a particular classifier has reached accuracy (or precision) higher than its threshold, agents A3 and A4i send the result to agent A5 that collects and outputs the report on the student solution. In the case that a threshold has not been reached, messages are sent back to A2 demanding for completion of the set of frequent subgraphs, actually in decreasing minimum support and subsequently, learning new subgraphs. If the minimum support reaches the limit (see parameters), the system stops.

We partially followed the solution introduced in (Zhang, 2004). The main advantage of this solution is its flexibility. The most important feature of the solution that is based on agents is interaction among agents in run-time. As each agent has a strictly defined interface it can be replaced by some other agent. New agents can be easily incorporated into the system. Likewise, introduction of a planner that would plan experiments will not cause any difficulties. Now we focus on two main agents—the agent that learns frequent patterns and on the agent that learns from data where each attribute corresponds to a particular frequent subgraph and the attribute value is equal to 1 if the subgraph is present in the resolution tree and equal to 0 if it is not. The system starts with a maximum support and learns a kind of frequent patterns, based on the parameter settings. In the case that the accuracy is lower than the minimum accuracy demanded, a message is sent back to frequent pattern generator. After decreasing the minimum support the generator is generating an extended set of patterns, or is selecting only emerging patterns. The system has been implemented mostly in Java and employs learning algorithms from Weka (Hall et al., 2009) and an implementation of SLEUTH.

4.2 Generalized Resolution Subgraphs

4.2.1 Unification on Subgraphs

To unify different tasks that may appear in student tests, we defined a unification operator on subgraphs that allows finding of so called *generalized subgraphs*. Briefly saying, a generalized subgraph describes a set of particular subgraphs, e.g., a subgraph with parents $\{A,-B\}$ and $\{A,B\}$ and with the child $\{A\}$ (the result of a correct use of a resolution rule), where A, B, C are propositional letters, is an instance of generalized graph $\{Z,-Y\}$, $\{Z,Y\} \rightarrow \{Z\}$ where Y, Z are variables (of type *proposition*). The example of incorrect use of resolution rule $\{A,-B\}$, $\{A,B\} \rightarrow \{A,A\}$ matches with the generalized graph $\{Z,-Y\}$, $\{Z,Y\} \rightarrow \{Z,Z\}$. In other words, each subgraph is an instance of one generalized subgraph. We can see that the common set unification rules (Dovier et al., 2001) cannot be used here. In this work we focused on generalized subgraphs that consist of three nodes, two parents and their child. Then each generalized subgraph corresponds to one way—correct or incorrect—of resolution rule application.

4.2.2 Ordering on Nodes

As a resolution proof is, in principal, an unordered tree, there is no order on parents in those three-node graphs. To unify two resolution steps that differ only in order of parents we need to define ordering on parent nodes[1]. We take a node and for each propositional letter we first count the number of negative and the number of positive occurrences of the letter, e.g., for $\{-C,-B,A,C\}$ we have these counts: (0,1) for A, (1,0) for B, and (1,1) for C. Following the ordering Ω defined as follows: $(X,Y) \leq (U,V)$ iff $(X < U \vee (X = U \wedge Y \leq V))$, we have a result for the

[1]Ordering on nodes, not on clauses, as a student may write a text that does not correspond to any clause, e.g., $\{A,A\}$.

node $\{C,-B,A,-C\}$: $\{A,-B,C,-C\}$ with description Δ = ((0,1), (1,0), (1,1)). We will compute this transformation for both parent nodes. Then we say that a node is smaller if the description Δ is smaller with respect to the Ω ordering applied lexicographically per components. Continuing with our example above, let the second node be $\{B,C,A,-A\}$ with Δ = ((0,1), (0,1), (1,1)). Then this second node is smaller than the first node $\{A,-B,C,-C\}$, since the first components are equal and (1,0) is greater than (0,1) in case of second components.

4.2.3 Generalization of Subgraphs

Now we can describe how the generalized graphs are built. After the reordering introduced in the previous paragraph, we assign variables Z,Y,X,W,V,U,... to propositional letters. Initially, we merge literals from all nodes into one list and order it using the Ω ordering. After that, we assign variable Z to the letter with the smallest value, variable Y to the letter with the second smallest value, etc. If two values are equal, we compare the corresponding letters only within the first parent, alternatively within the second parent or child, e.g., for the student's (incorrect) resolution step $\{C,-B,A,-C\},\{B,C,A,-A\} \rightarrow \{A,C\}$, we order the parents getting the result $\{B,C,A,-A\},\{C,-B,A,-C\} \rightarrow \{A,C\}$. Next we merge all literals into one list $\{B,C,A,-A,C,-B,A,-C,A,C\}$. After reordering, we get {B,-B,C,C,C,-C,A,A,A,-A} with Δ = ((1,1), (1,3), (1,3)). This leads to the following renaming of letters: $B \rightarrow Z$, $C \rightarrow Y$, and $A \rightarrow X$. Final generalized subgraph is $\{Z,Y,X,-X\},\{Y,-Z,X,-Y\} \rightarrow \{X,Y\}$. In the case that one node contains more propositional letters and the nodes are equal (with respect to the ordering) on the intersection of propositional letters, the longer node is defined as greater. At the end, the variables in each node are lexicographically ordered to prevent from duplicities such as $\{Z,-Y\}$ and $\{-Y,Z\}$.

4.3 Classification of Correct and Incorrect Solution

For testing of algorithm performance we employed 10-fold cross validation. At the beginning, all student solutions have been divided into 10 groups randomly. Then for each run, all frequent three-node subgraphs in the learning set have been generated and all generalization of those subgraphs have been computed and used as attributes both for learning set and for the test fold. The results below are averages for those 10 runs.

We used four algorithms from Weka package, J48 decision tree learner, SMO Support Vector Machines, IB1 lazy learner and Naive Bayes classifier. We observed that the best results have been obtained for minimum support below 5% and that there were no significant differences between those low values of minimum support.

The best results have been reached for generalized resolutions subgraphs that have been generated from all frequent patterns, i.e. with minimum support equal to 0% found by Sleuth (Zaki, 2005). The highest accuracy 97.2% was obtained with J48 and SMO. However, J48 outperformed SMO in precision for the class of incorrect solutions—98.8% with recall 85.7%. For the class of correct solutions and J48, precision reached 97.1% and recall 99.7%. The average number of attributes (generalized subgraphs) was 83. The resulting tree is in Fig. 3. The worst performance displayed Naive Bayes, especially in recall on incorrect solutions that was below 78%. Summary of results can be found in Table 1.

If we look at the most frequent patterns which were found, we will see the coincidence with patterns in the decision tree as the most frequent pattern is $\{Z\},\{-Z\} \rightarrow \{\#\}$ with support 89%. This pattern is also the most frequent for the class of correct proofs with support 99.7%, next is $\{Y,Z\},\{-Y,Z\} \rightarrow \{Z\}$ with support 70%. Frequent patterns for incorrect proofs are not necesarilly interesting in all cases. For example, patterns with high support in both incorrect and correct proofs are mostly unimportant, but if we look only at patterns specific for the class of incorrect proofs, we can find common mistakes that students made. One such pattern is $\{Y,Z\},\{-Y,-Z\} \rightarrow \{\#\}$ with support 32% for the incorrect proofs. Other similar pattern is $\{-X,Y,Z\},\{-Y,X\} \rightarrow \{Z\}$ with support 28%.

4.4 Complexity

Complexity of pattern generalization depends on the number of patterns and the number of literals within each pattern. Let r be the maximum number of literals within a 3-node pattern. In the first step, ordering of parents must be done which takes $O(r)$ for counting the number of negative and positive literals, $O(r\log r)$ for sorting and $O(r)$ for comparison of two sorted lists. Letter substitution in the second step consists of counting literals on merged list in $O(r)$, sorting the counts in $O(r\log r)$ and renaming of letters in $O(r)$. Lexicographical reordering is performed in last step and takes $O(r\log r)$. Thus, the time complexity for whole generalization process on m patterns with duplicity removal is $O(m^2 + m(4r + 3r\log r))$.

Table 1: Results for frequent subgraphs.

Algorithm	Accuracy [%]	Precision for incorrect proofs [%]
J48	97.2	98.8
SVM (SMO)	97.2	98.6
IB1	94.9	98.3
Naive Bayes	95.9	98.6

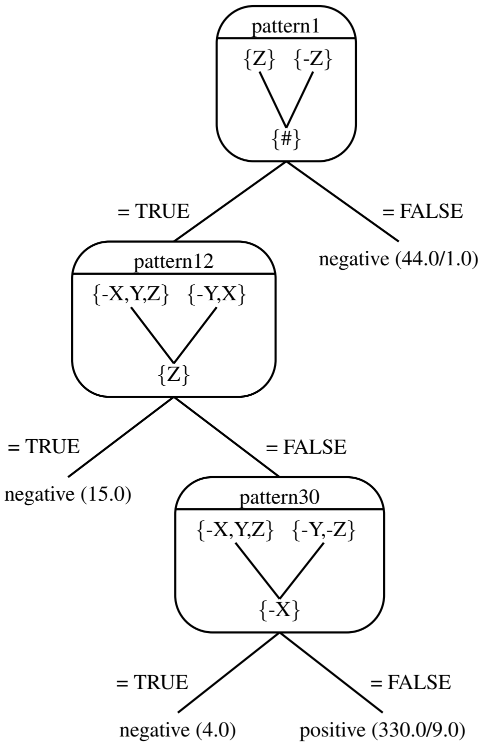

Figure 3: Decision tree with subgraphs as nodes.

Now let the total number of tree nodes be v, number of input trees n, the number of patterns found by Sleuth m, the maximum number of patterns within a single tree p, time complexity of Sleuth $O(X)$, time complexity of sleuth results parsing $O(Y)$, time complexity of classifier (building and testing) $O(C)$. Furthermore, we can assume that $m \gg p$, $m \gg n$ and $m \gg r$. Then the total time complexity of 10-fold cross validation is $O(m^2 + nmp + v + X + Y + C)$.

5 DISCUSSION

5.1 Emerging Patterns

We also checked whether emerging patterns would help to improve performance. All the frequent patterns were ranked with GrowthRate metric (Dong and Li, 1999) separately for each of the classes of correct and incorrect solutions. Because we aimed, most of all, to recognize wrong resolution proofs, we built two sets of emerging frequent patterns where the patterns emerging for incorrect resolution proofs have been added to the set of attributes with probability between 0.5 and 0.8, and the emerging patterns for the second class with probability 0.5 and 0.2, respectively. Probability 0.5 stands for equilibrium between both classes.

It was sufficient to use only 10–100 top patterns according to GrowthRate. The best result has been reached for 50 patterns (generalized subgraphs) when probability of choosing an emerging pattern for incorrect solution has been increased to 0.8. Overall accuracy overcome 97.5% and precision on the class of incorrect solutions reached 98.8% with recall 87.3%. It is necessary to stress that the number of attributes was lower, only 50 to compare with 83 for experiments in Table 1. We again used 10-fold cross validation.

5.2 Classification into Three Classes

To increase precision on the class of incorrect proofs, we decided to change the classification paradigm and allow the classifier to leave some portion of examples unclassified. The main goal was to classify only those examples for which the classifier returned high certainty (or probability) of assigning a class.

We used validation set (1/3 of learning examples) for finding a threshold for minimal probability of classification that we accept. If the probability was lower, we assigned class UNKNOWN to such an example. Using 50 emerging patterns and threshold 0.6, we reached precision on the class of incorrect solutions 99.1% with recall 81.6% which corresponds to 73 examples out of 90. It means that 17 examples were not classified to any of those two classes, CORRECT and INCORRECT solution. Overall accuracy, precision and recall for the correct solutions were 96.7%, 96.2% and 99.4%, respectively.

5.3 Inductive Logic Programming

We also checked whether inductive logic programming (ILP) can help to improve the performance under the same conditions. To ensure it, we did not use any domain knowledge predicates that would bring extra knowledge. For that reason, the domain knowledge contained only predicates common for the domain of graphs, like node/3, edge/3, resolutionStep/3 and path/2. We used Aleph system (Srinivasan, 2001). The results were comparable with the method described above.

6 CONCLUSION AND FUTURE WORK

Our principal goal was to build a robust tool for an automatic evaluation of resolution proofs that would help teacher to classify student solutions. We showed that with the use of machine learning algorithms—namely decision trees and Support Vector Machines—we can reach both accuracy and precision higher than 97%. We showed that precision can be even increased when small portion of examples was left unclassified.

The solution proposed is independent of a particular resolution proof. We observed that only about 30% of incorrect solutions can be recognize with a simple full-text search. For the rest we need a solution that employs more sophisticated analytical tool. We show that machine learning algorithms that use frequent subgraphs as boolean features are sufficient for that task.

As future work we plan to use the results of this system for printing report about a particular student solution. It was observed, during the work on this project, that even knowledge that is uncertain can be useful for a teacher, and that such knowledge can be extracted from output of the learning algorithms.

ACKNOWLEDGEMENTS

This work has been supported by Faculty of Informatics, Masaryk University and the grant CZ.1.07/2.2.00/28.0209 Computer-aided-teaching for computational and constructional exercises. We would like to thank Juraj Jurčo for his help with data preparation.

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e-Teaching Assistant
A Social Intelligent Platform Supporting Teachers in the Collaborative Creation of Courses

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Keywords: Social Networks, Materials' Quality and Reuse, User Reputation, Gamification, Recommendation System.

Abstract: With the ambition of providing teachers with a concrete tool for worldwide exploiting didactic contents to feature their courses, we face the problem of creating a social platform with adequate functionalities to satisfy the teacher expectations. Starting with a well designed architecture we endow it with three key functionalities that become the stakeholders of the emerging social network: 1) a quality system ensuring the value of the materials the users put in the platform repository as their contribution to the social business, 2) a recommender system based on computational intelligence techniques constituting the principal tool to guide teachers along the assembling of materials into courses, and 3) a gamification system, root of the no-profit business plan of the platform, to involve teachers in the social network. As a result we delineate an ecosystem where teachers exploit contents of a repository to which contribute by themselves. They are encouraged in exploiting and contributing because the contents are of high quality; they are wisely assisted in the exploration of the repository by platform services yet under their full control; and they are variously reworded by this involvement.

1 INTRODUCTION

In the last few years we have observed the proliferation of platforms (like Merlot, Connexions, OpenLearn, ARIADNE, MACE, Share.TEC) that make available to teachers didactic materials that can be used for teaching. Moreover, multimedia representation models like Learning Object – LO (Wiley, 2000), Open Educational Resources – OER (Atkins et al., 2007), and SCORM (ADL - Advances Distributed Learning, 2004), have been proposed for enhancing the interoperability of platforms in representing and exchanging didactic resources. By means of these platforms/models and also the materials made available on the Web by Schools and Universities, a huge amount of didactic materials is available that could be adopted (or acquired when subjected to fees) for the preparation of single lessons or entire courses. In this overwhelming of information, however, it is not easy to discover the right materials that meet the preparation and expectation of the class students. Moreover, the quality of the resources is not always the same, the level of detail of the treated topics ranges differently from elementary to very detailed and advanced presentations, and the requirements for effectively attending to the materials are not always clear. Therefore, teachers wishing to reuse already developed materials spend hours in the retrieval of adequate lectures, exercises and projects for their classes, succeeding only seldomly in finding the right ones.

In this paper we wish to detail the characteristics of a tool, named *e-Teaching Assistant*, specifically tailored for helping and supporting teachers in the process of preparation and sharing of didactic resources (either single materials or entire courses). This tool is designed by considering teachers as "demanding-users", namely individuals that, accustomed to produce educational materials and having clear ideas on the topics to be taught according to the level of preparation of the class to which they are intended, do not expect to receive "pre-defined" instructions on how to create and organize their courses; rather, they demand to both interact with the system and discuss and collaborate with domain experts. A key characteristic of e-Teaching Assistant is that users can formally or informally collaborate for the realization of courses by means of a social network (SN) specifically tailored for this context. Moreover, intelligent services, denoted as "meta-services", are devised for our demanding users, supporting them in the preparation, retrieval and exchange of materials. Among them, we point out: the reviewing service for improving the quality

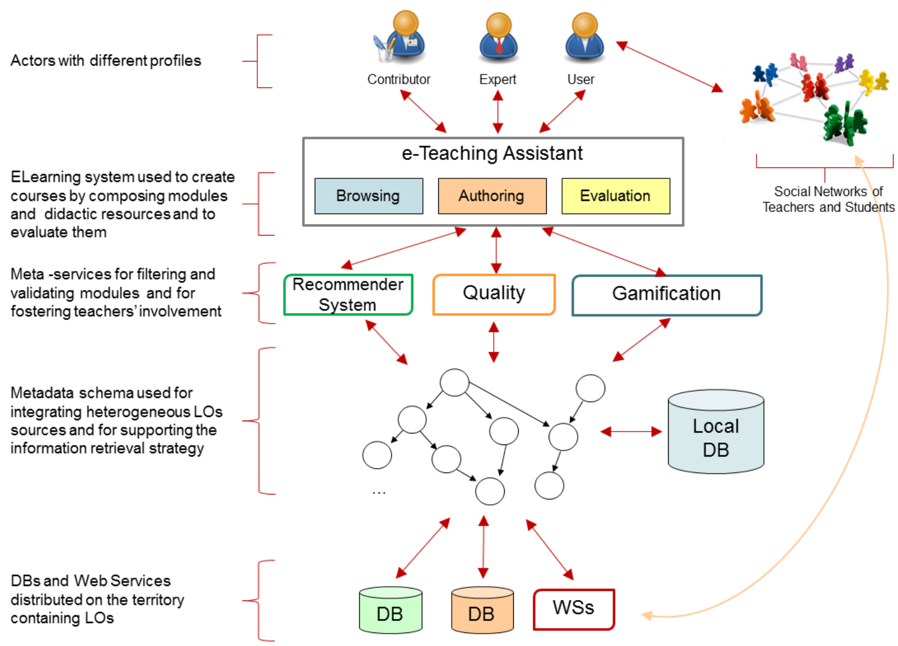

Figure 1: e-Teaching Assistant Architecture.

of the published materials by taking into account the characteristics of the students to which they are devoted (language, age, student backgrounds, and objectives); the recommendation service for the identification of suitable materials; composition services to generate new courses by reusing materials developed by other colleagues, still keeping the provenance of the materials; gamification services for encouraging teachers in proactively participating to the platform.

This paper presents our thoughts on how these meta-services should be integrated to forecast a social intelligent learning management system for demanding users. We start with an overview of the whole architecture, giving prominence to the enhancements w.r.t. state-of-the-art e-learning platforms. Then, we highlight the features of the proposed recommendation and gamification systems, in order to face the distinctive peculiarity of the afforded task.

We are currently experimenting this new paradigm in the framework of the NETT European project (nett-project.eu), where these services aim to help teachers to improve the provision of courses for improving the entrepreneurship (Valtolina et al., 2014). This discipline is crucial in the education of young generations, yet not well assessed as a corpus of basic lessons and those orienting the learner to a given specialization. We face this immaturity by a cognitive recommendation system, as for advanced service, and a gamification system, as for gathering community members and their evaluations at the basis of the former. In this short note we will discuss these tools from a methodological perspective, having our experience in NETT as a workbench.

2 ARCHITECTURE AND QUALITY OF THE MATERIALS

In recent years many e-learning platforms have been devised, like Merlot, Connexions, OpenLearn, ARIADNE, MACE and Share.TEC, mainly focused on handling single resources (like powerpoint presentations, pdf files, exercises and so on). In Merlot and Share.TEC the architecture relies on the definition of ontological structures to support the sharing of digital content. In particular, Share.TEC proposes an ontology called TEO (Teacher Education Ontology) (Ivino et al., 2009) to provide a powerful tool for cataloging and classifying materials capable to provide personalized access to didactic resources, based on the actual users needs, their cultural context, and their professional profile. Even though these systems provide some SN capabilities, they are quite limited and not well integrated in the entire process of production and use of the developed resources.

The architecture to be devised for e-Teaching Assistant should meet the following requirements:

- Didactic materials should be handled at different levels of aggregation, ranging from single resources to modules and courses, where a module is an aggregation of single resources and a course is an aggregation of modules. In this way, teachers can have a more complete overview of how the course and other ancillary materials (like articles, exercises, discussion) associated to a module or an entire course are organized by other colleagues.

- Each course, module or single resource is associated with a set of metadata that describes the didactic materials and give meaning to them. By starting from the standard LOM (IEEE, 2006) we consider a small subset that aptly conform to the context under consideration. Note that: the metadata for modules (and in turn those for courses) can be automatically extracted from the annexed resources; and, multiple values can be specified for the same property (e.g. the language of the module is the union of those used in its contents).
- Exploiting the result of the Merlot and Share.TEC projects, we extend and integrate our metadata structure using the OAI-PMH protocol for the selective gathering of metadata describing learning objects[1]. Through this protocol, our metadata structure is extended in an ontology able to allow personalized access to the educational materials and to offer an effective strategy for integrating different didactic content sources.
- The didactic materials are not forced to be stored within e-Teaching Assistant. Materials can be present in other platforms or made available through web services. However, their metadata are locally stored and exploited by the metaservices. External materials might also be subjected to the payment of royalties to their authors or to the platforms where they are stored.
- A SN should be deeply integrated in the system in order to offer social metaservices for the creation of communities around the topics covered by e-Teaching Assistant and the support of peers in all the phases of the creation, revision, audit and publication of didactic materials as well. The actors of the SN are classified in Visitors, Contributors, Masters (leaders in given topics), and Experts (contributors with large experiences). These roles will dynamically change, according to the level of participation to the network.
- Levels of reputations of the SN members, levels of appreciations of the developed materials, provenance of the developed materials, and their reuse will be associated to the actors and materials handled by the system, maintained up-to-date and exploited by the available metaservices as well.

At any level of the education system, an e-learning platform needs to face issues concerning the quality of didactic materials offered to students. In Merlot a reviewing system similar to the one adopted in the context of publication of journal papers is used. Moreover, all the cited platforms support the grading of the materials using different scaling (either from 0 to 5 or from 0 to 10): an information that is only used for ranking the materials when they are retrieved.

In e-Teaching Assistant we will adopt the aforementioned solutions to guarantee the quality of the developed materials, enhancing them by:

- integrating the reviewing activities with comments and ideas coming from the SN. The SN should thus become a mean for exchanging ideas, comments and solutions for better facing the learning issues of students. Both formal and informal communications will be granted to teachers belonging to the same community;
- linking the quality of the developed materials with the respectability of the teachers producing them. In this way, teachers are encouraged to produce high quality materials to improve their respectability in the community. The use of levels of respectability has also the advantage of identifying masters of given topics and experts that can help the former in the reviewing processes.

3 COMPOSITION OF COURSES

The core business of e-Teaching Assistant is the composition of new courses. To this aim teachers are guided to both organize courses as a wise sequence of modules and to fill up modules with resources that comply with their didactic goals and cultural preferences. Thus, besides the traditional tools for retrieving didactic materials based on keywords and metadata matchings, the intelligence of e-Teaching Assistant is represented by a computationally intelligent recommendation system based on both metadata and user consensuses variously collected through the common social tools of the SN.

Actually, Recommendation System (RS) is a relevant component of every modern SN in most disparate fields, ranging from movies, music, books, to financial services. Usually implemented as a web application, it constitutes a class of algorithms aimed at predicting user responses to options, by generating meaningful recommendations to a collection of users for items that might interest them.

[1]OAI-PMH is the Open Archives Initiative Protocol for Metadata Harvesting (http://www.openarchives.org/pmh/) whose aim is to create an independent interoperability framework based on metadata harvesting.

In e-Teaching Assistant, RS will focus primarily on the exploitation of didactic materials available in already developed platforms that take into account the characteristics of both teachers and students in terms of backgrounds, competences, language, and level of instruction. Moreover, in order to recommend materials with high quality, it will exploit social aspects such as the interaction between teachers and students, their reputation, and the respectability they have gained in the network. Such social context well embraces the proliferation of open educational resources (OERs) released under Creative Commons licenses, and the variability of the characteristics of the community of users involved in the educational process as well. On the one hand the heterogeneity of the on-line material, developed in different languages and with different quality for a variety of target students in different contexts of learning, complicates the realization of useful RSs. On the other hand, teachers are rarely satisfied by predefined and non-flexible recommendations when they exploit materials developed by other colleagues. Moreover, students having different background, culture and level of instruction need specific recommendations to support the discovery of suitable materials according to their aims, interests, and didactic needs. Finally, both teachers and students are tightly connected by means of SNs through which they can chat, exchange materials, and give evaluations on the resources available in a recommendation. Traditionally, RS are classified as:

- *Collaborative Filtering (CF) Systems*, where predictions about the interests of a user are inferred on the basis of people having similar interests and preferences. They are based on k-nearest neighbor (kNN) methods (Breese et al., 1998) as for Neighborhood-based approach and parametric estimation techniques as for Model-based approach (Bell et al., 2009).
- *Content-Based (CB) Systems*, where recommendations rely on the user's preference and the items' descriptions. They are based on query and relevance/similarity scores as for IR approaches (Mooney and Roy, 2000), and on classifiers of ⟨content, user-rating⟩ pairs, such as Naive Bayes (Pazzani and Billsus, 1997) and kNN classifiers, decision trees, and neural networks (Melville et al., 2002) as for Classifier.
- *Hybrid Recommendation Systems*, combining the above approaches in order to mitigate the associated limitations, for instance via boosting techniques (Schein et al., 2002) or generative models (Kim and Ahn, 2012).

Recent studies have attempted to use techniques for studying social relationships in terms of network theory, the Social Network Analysis (SNA), in combination with RSs. In (Brusilovsky, 1996) the authors got encouraging results by assigning weights to the content-based attributes used for recommendations as a function of their importance for users. In the e-learning context, several RSs have been developed to propose courses, materials, and relevant topics in forums (Brusilovsky, 2012). Although increasingly popular, so far only few studies such as (Frias-Martinez et al., 2006; Mulwa et al., 2010) have been addressed to suggest collaborative learning resources.

These methods are not sufficient to make satisfactory suggestions, mainly for the following reasons:

1. The inability to treat the uncertainty of both the ratings/suggestions and the resource description proposed by the SN members. In fact, judgments collected from a plethora of users with different habits and cultures may produce contradictions which in turn result in data having a high degree of ambiguity. This calls for a granular interpretation of the information provided by such crisp attributes, for instance in terms of fuzzy sets, rough and interval sets, and so on (Apolloni et al., 2008).
2. The lack of interpretability of the recommendation model and, as a consequence, of the recommendation policy.
3. The lack of user interaction. With the advancement of computational techniques, we have the unprecedented ability to allow machines to assist users in completing their tasks. Thus, fully automatic suggestions may not be entirely appreciated by the active user, which risks to get frustrated in using the RS platform whenever its recommendations prove to be erroneous.
4. The inability of current RSs to highlight the social relationships between users. This is especially important within a SN where each user will certainly appreciate receiving recommendations from those considered "closest" to her (classmates, teachers, etc.) (Shinha and Swearingen, 2001).

We expect e-Teaching Assistant to overcome these limitations by embedding computational intelligence into a hybrid system through the following features:

i) a Rule-Based System (RBS), to provide the user with an interpretable recommendation policy. We focus on a special instance of a decision tree algorithm, exploiting the one-to-one correspondence between decision trees and RBSs.

ii) Granular Computing techniques (Apolloni et al., 2008), which are essential to handle non crisp judgments. By fuzzifying the sets constituting antecedents and consequents of the RBS, we will introduce a fuzzy reasoning based on fuzzy entropic criteria and expressed in terms of fuzzy decision trees. To avoid injecting inconsistencies in the final rule set, the tree construction will be compliant with the multivalued attributes characterizing modules and contents of our repository.

iii) Interactive Machine Learning techniques, to allow the user to interactively participate in the development of the final recommendation. The development of a RS guided by the user intervention translates in dynamic modifications, backtracking included, of the rule set on the basis of the user input. In turn, the system will provide the most valuable suggestions satisfying the (explicit and implicit) constraints introduced by the user, such as presence of introductory courses, constraint on the course duration, and so on.

iv) Social Network Analysis (SNA), to capture social relationships among users. We will work on *ad hoc* clustering techniques for finding groups within the SN members. In this way, we will replace the concept of proximity of the typical CF algorithm with the corresponding SNA one, introducing weights on the preferences of the users, so that well-reputed members of the SN will have a higher influence in the whole process.

4 TEACHERS' INVOLVEMENT STRATEGIES

The SN life is made up of social activities, by definition. This implies that a SN may survive the initial enthusiastic period where the network is designed and its mockup is implemented only if the platform is populated by a community of users who have concrete motivations for interacting and sharing knowledge. Having decided for an open platform that is not rooted on a profit business model, we identified gamification as a relevant tool for fostering the user interest. Gamification indeed is a familiar context in the teaching framework for two reasons:

1. Students are in a continuous competition as a natural status of their job. It is a competition which is primarily toward themselves: they try improving themselves everyday, hence compete and overwhelm their own abilities. Actually several types of games are used in classroom activities (eLearn Magazine Staff and Contributors, 2011; Muntean, 2011; Raymer, 2011) based on typical game elements like time, accuracy, point systems integrated into training programs.
2. Teachers are in continuous competition (Nah et al., 2013) toward three frontlines: 1) themselves as former students, 2) students, to whom they can never yield, and 3) colleagues for both immaterial (pride) and material (carrier) reasons.

We plan leveraging on this competition for engaging teachers in creating and sharing materials. This type of metaservice is designed as an incentive system based on a set of rules that encourage teachers to explore and learn the properties of their possibility space. We adapt the common strategies (Deterding et al., 2011) to the above competition line in terms of:

- Frontline n°1
  1. *A layering mechanism* which allows teachers to learn new skills incrementally, and then practice those skills before demonstrating their mastery in creating new materials. Hence they are incrementally challenged to featuring contents, modules and finally entire courses.
  2. *A character upgrade scenario* which provides feedback to teachers for warning about how much progress they have made in creating a course. They gather virtual goods and assets to change the character in the way they like.
- Frontline n°2
  1. *Private or closed community groups*, which provide their agreement on the material produced by teachers according to their acquired competencies and rules. In fact, the overwhelming success and influence of social media in modern society corroborates the power of other people's opinion.
  2. *Objective indexes* such as number of downloads of the single contents by students, cumulated scores expressed by them, etc, which are a direct way of acknowledging the teachers work.
- Frontline n°3
  1. *Keeping the authorship* of the developed materials and the acknowledgment of the work done, that is very relevant for teachers. A contributor can integrate a module developed by another teacher and decide to keep it "as is" or to modify it (by adding or removing content). The system keeps track of the fact that the module is duplicated from an existing one, and the compliance (or not) with the original form. This feature is useful for maintaining the provenance of the material and to ensure the author' royalties and for incrementing his/her reputation.
  2. *Making teachers talking to one another*, which gives them common goals and rewards, especially if that reward is predicated on group par-

ticipation. Teacher's peers see when they collect these rewards. These extrinsic rewards are much more effective if people can use them for bragging rights, rather than just having some extra trophy graphic that nobody else will see.

A final remark on the game design concerns the whole presentation of the metaservices. The design, the look and feel, the interaction style and the communication process of the e-learning environment need a specific care and an incremental production of mock-ups anytime that new users requirements appear. Moreover, it is import to test our prototype as early as possible. One of the most repeated mistake is to make assumptions about how the target audience will use the product. The only way the designers can understand it is to put the system in front of them, watch them use it, and to document the experience in order to pay attention to how long it takes to make the correct input, and to watch through teachers' eyes for seeing where they look first on the screen mockups.

5 CONCLUDING REMARKS

The main goal of the *e-Teaching Assistant* is to offer a new opportunity for supporting teachers by exploiting the contributions of a SN able to enhance and enrich didactic contents proposed by their members. To this aim, the paper proposes a social oriented solution based on three metaservices for exchanging high quality didactic materials, retrieving content through a computationally intelligent recommendation service and stimulating the teachers involvement through gamification strategies. Other metaservices are under design for offering a semi-automatic combination of modules according to the requirements and skills characterizing them and by fitting the teachers' expectation according to their profile and background.

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Collaborative Annotation of Recorded Teaching Video Sessions

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Keywords: Collaborative Annotation, Learning Video, Note-taking, Web Application.

Abstract: Driven by technology advances the availability of digital video recordings of live training sessions increases at a fast pace. The goal of our research is to better understand the impact of these digital artifacts on the individual (and possibly collaborative) note-taking process of learners. In this paper, we develop a conceptual framework describing the augmentation of teaching sessions by computer-supported tools. We use the framework to describe related work and to outline our research design that involves the development of a minimum viable collaborative annotation tool and the study of the effects of variations in tool functionality (like visibility of annotations, kinds of annotations, or form of annotations) on the learning process. The scientific contribution of the conceptual framework and tool are to serve as a starting point for empirical research by us and others who analyses the effect of variations in collaborative annotation tool design.

1 MOTIVATION AND INTRODUCTION

Today a number of computer-supported solutions aim to improve student learning behavior and performance in the classroom environment. The main enablers for these changes are availability and price reduction of broadband internet as well as portable hardware, like, smartphones, laptops and tablets (Alvarez, 2011). For example, using mobile and web services, without interruption of the teacher's presentation, students have the possibility to interact between each other simply texting on Facebook or Twitter (M.D. Roblyera, 2010) (Gabriela Grosseck, 2008), to give a live feedback to the teacher (Veronica Rivera-Pelayo, 2013) and to collaborate on the presented material (Kam, 2005).

Another important change is that today teaching sessions are often recorded, that allows students to re-view the presented material as many times as they need. According to a survey conducted at the beginning of 2013 at the Technical University of Munich, 86% of the students considered the possibility to watch lecture video recordings as important or very important (Technische Universität München, 2013). 1353 students took part in this survey. About two-thirds of the participants claimed that lecture recordings are used by them for follow-up of the courses and for exam preparations. Only 2% of the students stated that audio recordings were sufficient.

Another technology-enabled change in the educational system is the concept of Massive Online Open Courses (MOOCs). Students interested in a particular subject have the ability to acquire freely available qualitative educational content (Lane, 2013). MOOCs also build on the idea of teaching sessions but address a much wider audience outside of the classroom and also make heavy use of video recordings.

As a result, the amount of educational digital content and tools for handling this content grows rapidly. In institutions where teaching session attendance is not mandatory, new educational solutions and services create a free-market environment enabling students to vote with their feet to attend lectures live, to watch teaching sessions online, or to skip lectures entirely (Scott Cardall, 2008). This is an example of a significant change of behavior introduced through digital media.

It remains unclear, how learners post-process educational content and what kind of services they use. Our research goal is to understand how learners annotate educational videos, to develop a minimum viable tool to assist students in this process and to study the effects of the tool on the behavior of instructors and learners. In the future, we plan to study effects of changes of the tool design (visibility

Table 1: Activities and content involved in a recorded live teaching session without additional computer-based tool support.

		Phases		
		Preparation	*Live teaching session*	*Post-processing*
Actors	*Instructor*	Plan timing of teaching session. Prepare teaching material. [Provide hand-out.]	Present teaching material. Interact with students. Record video.	Publish recorded video.
	Learner	[Process hand-out.] [Take notes.]	Follow presentation. [Interact with instructor.] [Interact with other learners.] [Take or review notes.]	[Watch recorded video] [Review notes.] [Share notes with other learners.]

of annotations, kinds of annotations, form of annotations, etc.) as well. In this position paper, we present the concepts underlying the tool, our research questions and existing work regarding the augmentation of teaching sessions in a unifying conceptual framework. The goal of this position paper is to get early feedback from the academic community in computer-supported education.

2 A CONCEPTUAL FRAMEWORK FOR DESCRIBING AUGMENTED TEACHING SESSIONS

This section introduces a conceptual framework to explain the *augmentation* of teaching sessions by video recording and annotation processes. We use this framework to describe related work and to explain our tool. In addition we clarify our terminology and link our concepts to existing research.

We use the general term *teaching session* to describe a lecture, an exercise session, a seminar or any kind of meeting where an instructor presents *teaching material* (educational content) to one or many learners. We call any teaching material made available by a teacher to a student a *hand-out* and any content created by a student a *note*. An *annotation* is a note added to a special part of teaching material.

In Table 1, we schematically illustrate a conceptual framework where **rows** introduce *actors* participating in the process. Up to now we only distinguish between two kinds of actors: *instructor* and *learner*.

Columns represent *phases* which help to describe the synchronous and asynchronous interactions (information flows) between actors over time. The *preparation* phase includes the set of activities aimed to prepare for the live teaching session. The live teaching session phase subsumes the synchronous interactions between actors and their interactions with possible content. The post-processing phase covers all actions performed by actors with content created in the first two phases.

Cells describe actors' activities (verbs) and content (nouns) involved in these activities. Optional activities are enclosed in brackets [].

Table 1 describes the basic collaborative process of a live teaching session recorded by a video without any additional computer-based tool support.

3 AUGMENTED TEACHING SESSIONS

3.1 Note-taking and Annotation without Use of a Special Tool

Steimle et al. survey 408 learners, where 316 were students in computer science and 92 were students in a pedagogy course (Steimle, 2007). No additional tool for note-taking had been offered to the learners. Table 1 provides an overview of the present study. The study showed that numerous key characteristics of traditional note-taking with pen and paper are comparable with those of electronic notes on a laptop. No differences between the two groups were found in the types of notes taken, both in the post-processing phase as well as in collaborative activities. It should be noted that in the context of this study collaborative activity means sharing hand written notes between students after a live teaching session, for example, to compare each other's notes, or copying notes in case one learner didn't attended the teaching session.

The study identified different types of content and their combination that were used to take notes on:

- printed slides;
- empty sheets of paper;
- empty sheets of paper and printed slides;
- laptop;
- laptop and empty sheets of paper;
- laptop and printed slides.

Different types of software, that allows to annotate the electronic course slides (e.g. Adobe Acrobat), or word processors and text editors, were used by learners for note-taking on the laptop. The data shows that the ratio between students annotating hand-outs and students taking notes on blank sheets did not change if compared to the students annotating slides on a laptop and students taking notes using text editors.

The authors state that the discipline proved to be an influential factor since laptop use differed largely between the disciplines. In the pedagogy course, laptop use was almost not existent and learners took notes exclusively on paper.

Moreover, different advantages of taking notes on paper and using laptop were identified. Learners taking notes on a laptop valued that:

- notes can be more easily modified;
- it offers a cleaner appearance;
- learners do not have to print the slides;
- a laptop allows them to keep the information in one place.

Those who take notes on paper stated that it is easier and faster than note-taking on a laptop. All participants valued the flexibility of free-form notes on paper.

Another interesting finding was related to the post-processing phase. The results show that in contrast to the follow-up activities after class, students become more active when preparing for the exam.

In conclusion, the following implications for future annotation systems were derived:

- support of handwritten input;
- support of both annotations and notes on blank pages;
- provide enough free space for annotations;
- support of several languages;
- support of collaboration;
- adaptability to the specific context.

This study suggests that note-taking behaviour largely depends on a complex multitude of context aspects. Annotation systems must account for this dependency. Therefore, they must be adaptable in their central functionality (like support for annotations vs. notes on blank pages, input modality, types of the notes and collaborative features) to fit the different user needs and teaching styles in specific context situations.

3.2 Annotation using Special Tool

Kam et al. developed a system for cooperative annotation in lectures (Kam, 2005). Table 2 shows what types of activities and content were involved in the overall process. To save place we do not include activities that were mentioned in Table 1, but it is considered that they were conducted as they are part of a usual educational process. Unfortunately, there is no information available on how the produced notes were used during the post-processing phase, nor about the availability of the teaching session video recordings.

The following activities have been identified when students create collaborative annotations of hand-outs:

- summarizing the entire slide;
- posing questions to provocative bullet points;
- answering questions framed as bullet points;
- appending items to a list of sub-bullet points;
- annotating specific bullet points;
- listing additional ideas, examples, and issues in response to bullet points;
- raising objections and alternative reasoning;
- criticising the choice of images or examples in slides;

Table 2: Activities and contents involved in a teaching session where an annotation tool has been offered to the learners.

		Phases		
		Preparation	*Live teaching session*	*Post-processing*
Actors	*Instructor*	Upload hand-outs to the system. [Give instruction how to use the provided tool.]	[Follow the real-time feedback.]	-
	Learner (with tool access)	-	Annotate the hand-out. Read and comment annotation. [Provide feedback about the speed of the teaching session.]	-

- explaining the meaning of abbreviations; and
- complaining that the proposed design steps in a slide do not apply to the problem at hand, and correcting these.

Learners also added new details to bullet points, especially when they contained examples.

In the collaboration environment learners appear to find it important to explicitly distinguish between teaching material and annotations.

The following implications were derived:

- The need to enable learners to bring the instructor into the loop whenever necessary, such as when learning difficulties surface that students cannot resolve on their own.
- Certain aspects of collaborative note-taking and dialogue are related to social expectations and norms. For instance, some collaboration groups seemingly broke down when the one or two members with tool access were not contributing to the shared note-taking and discussion.

It is noticeable that researchers at that time were struggling with the lack of efficient portable hardware and insufficient cross-platform technology for collaboration. However, the research showed how collaboration on the note-taking process changed the style of notes. Comparison of individual notes and collaborative group notes confirmed that the last one had far more comments, questions and answers. The study has shown that student interactions with presentation slides during teaching session alone are much broader and richer than simply capturing the spoken part of the lecture. Augmented note-taking or in other words annotation of instructors' content is likely to support cooperative learning greatly. Teaching material presented in the collaborative environment such as the instructors' slides can provide learning objects that invite learners to interact with them.

3.3 Web-based Tagging of Recorded Teaching Session

Shen et al. describe a web-based system that allows learners to collaboratively annotate a video stream using predefined tags (Shen, 2011). The video stream was broadcasted from the live teaching session. The authors argue that the cognitive gaps between different learners' note-taking are apparent, even though they are annotating the same teaching session slide. The collaborative learning may increase the redundancy rather than create learning efficiency. Due to this hypothesis and proposals of other researches (Bateman, 2007), the authors assume that collaborative tagging is one of the solutions that can improve collaborative annotation. In Table 3 we describe which actions and contents are involved in the overall process of the system.

The main feature of the system developed by Shen et al. (2011) is a wave-shape timeline chart where learners are able to see which predefined tags (good, question, disagree, etc.) that were used during a teaching session. That allows identifying hot spots of the recorded video and does not require a text input.

3.4 Collaborative Annotation Tool for Recorded Teaching Session Video

In this section we introduce our tool that is based on the idea of having a specific collaboration environment for the different phases of the teaching process: the live teaching session and the post-processing phases (see Table 4 on the next page). The activities and contents of Table 4 extend the activities and contents of Table 1.

The processes of note taking during the live teaching session may differ from the one in the post processing phase since in first case learners should follow the instructors' presentation and don't have much time to write long notes, while in the second case the recorded video can be stopped or replayed. As we observe from the previous studies, it was not convenient for learners to start using a tool for collaborative note-taking during the live teaching session until they got an instruction how to use it (Kam, 2005). At the same time, in the study of

Table 3: Activities and contents involved in a teaching session where a special tool for tagging and video viewing has been offered to the learners.

		Phases		
		Preparation	*Live teaching session*	*Post-processing*
Actors	*Instructor*	-	Broadcast video stream. Record the video.	-
	Learner	Access system.	Add tag to streaming video. View tag intensity chart.	View recorded video. Navigate through recorded video using tag intensity chart.

Table 4: Collaborative annotation for recorded teaching session video (see text).

		Phases		
		Preparation	*Live teaching session*	*Post-processing*
Actors	*Instructor*	-	View annotation.	View and create annotation.
	Learner	-	Create and view annotation.	Create and view annotation.

Table 5: Possible synchronous and assynchronous collaboration via video annotations. Arrows show possible synchronous and assynchronous collaboration.

		Phases		
		Preparation	*Live teaching session*	*Post-processing*
Actors	*Instructor*			
	Learner			

Steimle et al. (2007) learners use on their own standard software to annotate presentation slides or simple text editors to take notes. Therefore, the user interface for taking notes during a teaching session should have a similar user interface to commonly used software; in this case the tool will be easy to adopt.

To enable the transition of annotations during live teaching session to the post-processing phase we will synchronize the video stream with notes taken when the particular frame of the video was captured.

The most challenging part of the annotation system will be the collaborative aspect. As it will influence the user interface and have to be implemented in a way clearly understandable for users. Moreover, various collaboration scenarios have to be revised. In Table 5 we show possible collaboration activities related to the annotations during the overall process. Using this table we can observe what actors have to be present in the system and what rights for collaboration they will have during each phase.

As shown in Table 4 and Table 5 our minimal viable tool will only contain a small set of functionalities and collaboration scenarios. That is done on purpose, since at the beginning of our study we would like to evaluate only the basic functionality and avoid creating possibly unused and distracting functionality.

4 FUTHER RELATED WORK

There are a few researchers as well as commercial projects that study (video) annotation and retrieval processes during meetings in *enterprise* environments. Their results are relevant because a meeting with a presenter and an audience is similar to a teaching session.

Nathan et al. focus on the ability of people to retrieve information from a meeting, and provide a special tool for collaborative annotation of live meetings (Nathan, 2012). As repositories of such recorded video meetings grow, the value and utility of these stores will depend on providing tools that help users to quickly browse, find and retrieve elements of interest. Given the long time (and high costs) required to view a recorded meeting in its entirety, there is a need for tools that assist in efficient information retrieval. This is particularly true for people who missed a meeting, who frequently choose to learn about the proceedings from a colleague (Banerjee, 2005), rather than invest the time viewing its recording.

5 CONCLUSION AND FUTURE WORK

In this paper we presented the design of a minimum viable web-based tool for collaborative video annotations of teaching sessions based on findings of existing research and development regarding augmented teaching sessions. For this purpose we developed and used a unifying conceptual framework based on three phases, two types of actors, and activities using four types of artifacts (teaching material, hand-outs, notes and annotations).

The scientific contribution of the tool and the framework are to serve as a starting point for empirical research by us and others that studies the impact of variations in tool design (like the visibility of annotations in different phases, kinds of annotations and notes, form of annotations, and design of the user interface) on the behavior of the learners and also of the teacher.

We are currently implementing the tool using standard web technologies and are designing the experiments (research questions, hypotheses and measurement techniques) to be carried out in an iterative and incremental way starting with the minimum viable tool in the near future.

In our future work, we want to allow learners to create both, private and shared notes. This allows the learner to search only private notes.

Navigation should allow learners to jump from a particular annotation to the exact time of the video when it has been created.

A further extension would be to support two different ways of note representations in the system: One interface for “static” notes (relating to the whole teaching session) and another for annotations displayed dynamically (synchronized with the video).

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Identification of Behavior Patterns Within Graduated Students and Undergraduate Modules at the Technical University of Cartagena, Spain

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Keywords: Undergraduate Curricula, Learning Behaviour Patterns.

Abstract: As a consequence of the governmental decision to adapt the Spanish graduate and post-graduate studies to converge to the 'European Higher Education Area', the goal of the so-called Bologna Process, committees of experts were set up at the Technical University of Cartagena, located south of Spain, to design the new curricula that would build up the restructured offer of courses. It was decided to provide as supporting material to these committees statistical information about the academic behaviour and results of the students in modules of the existing courses. In this paper the main aspects of this study are presented, discussing the set of variables selected to characterize modules and students. Information about the structure of variability between students on one hand and between modules on the other hand is presented, based on a principal component analysis. Finally patterns were identified among modules and among students using a cluster procedure. The influence of relevant factors like gender, course and marks obtained at the School Leaving certificate on the resulting groups composition was explored as well.

1 INTRODUCTION

The Technical University of Cartagena, located south of Spain, offers a generalist engineering education, with emphasis in engineering fundamentals and practices attending approximately 6000 students. Nowadays, these undergraduate degrees usually involve five academic years and allow the students to continue their university education through the Doctor of Philosophy (PhD) degree. It is possible for the students to focus on a specific field of interest: mechanical, electrical, chemical, civil; within the last stages. A complete restructuration of the courses was undertaken in the last years as a consequence of the governmental decision to adapt the Spanish graduate and post-graduate studies to converge to the ‘European Higher Education Area’, the goal of the so-called Bologna Process, the inter-governmental process that promotes reforms in higher education with 47 countries. Consequently committees were set up on one hand on a national level, where experts from both academia and private sectors would establish a list of recommendations for the design of the new syllabuses, but also on a local level within each university, where representatives of each department involved in the teaching programs would concretely decide about the modules that would build up the curricula.

A statistical study of academic indicators computed from data collected during the last decade was then launched in our university. Two datasets were built: dataset S, consisting of more than 1000 students that successfully graduated from the School for Industrial Engineering at the Technical University of Cartagena, and dataset M, describing more than 200 modules along the last decade as well. The purpose of this study was to provide updated diagnostic regarding patterns of behaviour within the students and, simultaneously, identify groups of modules within the different courses that are offered, which would present homogeneity in terms of student behaviour. It must be emphasized that within the Spanish system, for a given module, each student has three opportunities to take the associated exam along a given academic year.

Moreover, it is not compulsory to pass successfully all the modules corresponding to a given stage in order to proceed to the next stage. As a consequence, a significant variability is observed between the student behaviours and strategies, resulting into variability between their trajectories within the university studies. Variability is also present therefore between modules. In this paper, the main results and conclusions of the statistical study are presented.

The rest of the paper is structured as follows. Section 2 gives a brief description about the most relevant variables used to provide, on one hand, information about the students' patterns of academic behaviour and, on the other hand, information that could help discriminating between modules. Section 3 presents preliminary results of an exploratory analysis of these variables. Multidimensional analysis techniques were then applied, and the results of a principal component analysis are discussed in Section 4. Finally, relevant conclusions are listed in Section 5.

2 VARIABLES AND FACTORS

As mentioned in Section 1, two multi-dimensional datasets S and M (Students data and Modules data respectively) are constructed by merging several university records databases. The essential one is the examination records database, but a student personal information database, is used to recover data like birth-date, gender or marks achieved at the School Leaving Certificate.

2.1 Data-Set *M*

For each module and each academic year from 2002/2003 to 2008/2009, the following variables have been computed:

- *TOOK_EXAM*: Within the students that registered for that module that year, proportion of students that took the exam at least in one out of the three possible opportunities.
- *PASSED_EXAM_REGISTERED*: Within the students that registered for that module that year, proportion of students that passed the exam.
- *PASSED_EXAM_TOOK_EXAM*: Within the students that took the exam for that module at least once out of the three possible opportunities, proportion of students that passed the exam.
- *OPP_TAKE_EXAM*: Within the students that took the exam for the first time that year, average number of opportunities they have had to take that same exam previously. This variable may require a little bit more explanation: since it is not compulsory for a student that has registered for a given module to take the exam, it happens that some students decide eventually not to take the exam in the first opportunity they have, neither in the second opportunity, or even end up not taking the exam at all that year. It is therefore of interest in particular to assess the perception that the students have regarding the difficulty of passing the exam associated to the module, to check, within the students that took the exam for the first time, how many times have they waited before daring to do it.
- *AVG_MARK*: Within the students that passed the exam that year, the average mark (on a 0 to 10 scale).
- *NUM_EXAM_PASS*: Within the students that passed the exam that year, the average number of times they had to take the exam to actually pass the module. It therefore amounts to the number of times they failed plus one.

2.2 Data-Set *S*

For each student that successfully graduated within the years 2001/2002 to 2008/2009 at the Industrial Engineering School, the following variables have been computed:

- *DURATION*: Relative duration of the studies, i.e. the number of years it took for the student to graduate divided by the number of stages in the course.
- *MARK*: Weighted average mark on a 0-10 scale. The weights are proportional to the ECTS assigned to each module.
- *OPP_TAKE_EXAM*: Within all compulsory modules, average number of opportunities that the student used to actually take the exam for the first time. (For more explanation, see Database M).
- *NUM_EXAM_PASS*: Within all compulsory modules, average number of times that the student had to take the exam to pass it (see as well Database M).

A series of additional variables or factors were also included to check their association with the variables of interest: gender, age at graduation, identification of the High School of origin, mark achieved at the School Leaving Certificate. (Called "*Selectividad*" in Spanish). The dataset S contains 1087 students.

3 FIRST DESCRIPTIVE INDICATORS

As a first step into the data exploration, a descriptive analysis was carried out making an intensive use of graphics and numerical indicators. A brief summary is presented in this Section to provide a sense of the orders of magnitude and the variability of the different variables.

3.1 Data-Set *M*

The dataset *M* contains the evolution of almost 200 modules over the considered academic years. Compulsory modules were only considered in this dataset, since optional modules present a high homogeneity in terms of student behaviours and performance. In Table 1, the first quartile, median, third quartile, mean, and standard deviation of the relevant variables are presented.

We may for example pinpoint a few figures out of Table 1: the average number of opportunities {*OPP_TAKE_EXAM*} that the students use to actually take an exam is close to 2, and some modules present really high values for that variable. On average almost 80% of the students that take at least once the exam of a module at the Industrial Engineering School pass {*PASSED_EXAM_TOOK_EXAM*}, while 70% of the registered students take the exam at least once. The number of times the students take an exam until they pass {*NUM_EXAM_PASS*} takes typically lower values than the number of opportunities that the students use to take the exam for the first time, a fact that already seems to anticipate that the perceived difficulty of a module before taking the exam is higher than the "real" difficulty to pass it.

From a quick check of the values of the Pearson correlation coefficients, we can emphasize the following:

- The highest correlation is found between the proportion of students that pass the exam with respect to the total number of registered students (*PASSED_EXAM_REGISTERED*) and the proportion of registered students that take the exam at least once: $cor(\mathit{PASSED\_EXAM\_REGISTERED},\mathit{TOOK\_EXAM})= 0.86$.
- The second highest correlation happens to be found between the proportion of registered students that pass the exam and the proportion of students that pass the exam with respect to the number of students that take the exam at least once: $cor(\mathit{PASSED\_EXAM\_REGISTERED},\mathit{PASSED\_EXAM\_TOOK\_EXAM})=0.75$. This is of course very natural; both variables depend directly on the number of students that pass the exam.
- The variables *PASSED_EXAM_TOOK_EXAM* and *NUM_EXAM_PASS* present a correlation of 0.66, which reveals a clear (and expected) association between the proportion of success when taking an exam and the average number of times the student has to take the exam before actually passing it.
- The lowest degrees of association are found between the variables *TOOK_EXAM* and *OPP_TAKE_EXAM* with the variables *NUM_EXAM_PASS*, *PASSED_EXAM_TOOK_EXAM* and *AV_MARK_10*, see values of correlations in Table 2, which tends to confirm that there is no strong relation between the perception of the student in terms of anticipating his possibilities of success at an exam (measured through his disposition to take the exam) and the actual difficulty to pass if he takes the exam.

3.2 Data-Set *S*

The dataset S contains 1087 students that successfully graduated from the Industrial Engineering School at the Technical University of Cartagena. 932 were male students while 155 were female students. In Table 2, the first quartile, median, third quartile, mean, and standard deviation of the relevant variables are presented. It may pointed out the high values that takes the variable *DURATION*, the centre of its distribution corresponding to an increment by 2 thirds of the expected "theoretical" duration before graduation.

This is explained partly by the fact that the students end their studies by a final project requiring full time investment while they also have to take modules until the end. They then usually begin an extra academic year to complete and present the project, which then adds one year to the absolute duration even if they actually use only a few extra months to do it.

On the other hand, half of the graduated students present in their academic trajectory an average close to 2 as for the number of opportunities they use before actually taking an exam, while the average of times they have to take the exam to pass it, is close to 1.

Table 1: Dataset M. Relevant variables.

NUM_REGISTERED	TOOK_EXAM	OPP_TAKE_EXAM	NUM_EXAM_PASS	PASSED_EXAM_REGISTERED	PASSED_EXAM_TOOK_EXAM	AV_MARK_10
Min. 1.0	Min 0.1667	Min 0.000	Min 0.000	Min 0.1239	Min 0.2609	5.000
1st Qu. 50.0	1st Qu. 0.5433	1st Qu. 1.443	1st Qu. 1.250	1st Qu. 0.3647	1st Qu. 0.6581	1st Qu. 5.867
Median 82.0	Median 0.667	Median 1.969	Median 1.571	Median 0.4921	Median 0.7778	Median. 6.176
Mean 90.65	Mean 0.6678	Mean 2.204	Mean 1.605	Mean 0.5273	Mean 0.7748	Mean 6.340
3rd Qu. 119.0	3rd Qu. 0.7987	3rd Qu. 2.770	3rd Qu. 1.885	3rd Qu. 0.6618	3rd Qu. 0.9104	3rd Qu. 10.00
Max. 296.0	Max. 1.000	Max. 11.33	Max. 3.091	Max. 1.000	Max. 1.000	Max. 10.00
Sd. 58.98	Sd. 0.17	Sd. 1.02	Sd. 0.43	Sd. 0.21	Sd. 0.16	Sd. 0.71

Table 2: Dataset M. Variable correlation results.

	NUM_EXAM_PASS	PASSED_EXAM_TOOK_EXAM	AV_MARK_10
TOOK_EXAM	-0.3015765	0.3496622	0.2827057
OPP_TAKE_EXAM	0.4034407	-0.3738091	-0.3646772

Table 3: Dataset S. Relevant variables.

AGE	MARK_SLC	DURATION	MARK_GRAD	OPP_TAKE_EXAM	NUM_EXAM_PASS
Min. 21	Min 5.020	Min 1.000	Min 5.350	Min 1.000	Min 1.000
1st Qu. 24	1st Qu. 6.274	1st Qu. 1.500	1st Qu. 6.100	1st Qu. 1.380	1st Qu. 1.200
Median 25	Median 7.066	Median 1.670	Median 6.390	Median 1.780	Median 1.380
Mean 25.27	Mean 7.055	Mean 1.792	Mean 6.478	Mean 1.918	Mean 1.446
3rd Qu. 26	3rd Qu. 7.752	3rd Qu. 2.000	3rd Qu. 6.755	3rd Qu. 2.310	3rd Qu. 1.615
Max. 49	Max. 9.680	Max. 4.500	Max. 9.490	Max. 6.220	Max. 3.000
Sd. 3.27	Sd. 0.97	Sd. 0.54	Sd. 0.55	Sd. 0.71	Sd. 0.34
	NA's 170000				

As for dataset M, a first glance at the correlation structure (see Table 4) reveals some interesting facts:

- The correlation between the mark achieved at the School Leaving Certificate MARK_SLC and the remaining variables is negative except with MARK_GRAD for which it is close to 0.5.
- There is a rather strong negative association between the variable *NUM_EXAM_PASS* and the final mark achieved at graduation, which seems to indicate that when the students have failed an exam, they usually do not achieve good marks when they finally pass.

A more complete exploratory analysis was performed by systematically splitting the datasets according to the levels of the considered factors, distinguishing between courses, students gender, high school of origin for dataset S and courses, stage, temporal location of the module for dataset M, and computing accordingly numeric indicators and displaying graphs.

4 PRINCIPAL COMPONENT ANALYSIS

Our interest was in particular in gaining understanding about the structure of variability between modules on one hand, and between students on the other hand. Among the considered variables, *which ones contribute the most to discriminating between modules or students?* A principal component analysis was then performed on the correlation matrix in both datasets.

4.1 Data-Set *M*

For dataset M the six variables: *TOOK_EXAM, OPP_TAKE_EXAM, NUM_EXAM_PASS, AV_MARK_10 PASSED_EXAM_REGISTERED,* *PASSED_EXAM_TOOK_EXA*M, were considered for the principal component analysis based on their correlation matrix. The proportion of variability explained by the first, the first two and the first three components is respectively 58%, 74% and 84%, and the expression of the first three components is the following:

PC1= 0.40 TOOK_EXAM - 0.37OPP_TAKE_EXAM + (-0.39)·NUM_EXAM_PASS + 0.50•PASSED_EXAM_REGISTERED + 0.43•PASSED_EXAM_TOOK_EXAM + 0.34 AV_MARK_10 (1)

PC2= (-0.59)•TOOK_EXAM + 0.31 OPP_TAKE_EXAM + (-0.46)•NUM_EXAM_PASS - 0.23 PASSED_EXAM_REGISTERED + 0.33 PASSED_EXAM_TOOK_EXAM + 0.42•AV_MARK_10 (2)

PC3= 0.03 TOOK_EXAM + 0.45 OPP_TAKE_EXAM + (-0.17)•NUM_EXAM_PASS + 0.26 PASSED_EXAM_REGISTERED + 0.46 PASSED_EXAM_TOOK_EXAM - (-0.70)•AV_MARK_10 (3)

The first component is clearly a weighted average of the different variables, assigning positive weights for the variables for which high values indicate good results and negative weights for the two variables for which low values indicate good results *OPP_TAKE_EXAM* and *NUM_EXAM_PASS*. The modules that score higher in this first component can thus be considered as the most successful modules, in terms of student behaviour and results. As for the second component the following interpretation is suggested: PC2 measures the difference between the difficulty perceived by the students before the exam and the actual difficulty to pass the module. Indeed it can be written as the sum of two terms: (-*TOOK_EXAM - PASSED_EXAM_REGISTERED + OPP_TAKE_EXAM*) and *(AV_MARK_10 + PASSED_EXAM_TOOK_EXAM - NUM_EXAM_PASS).* The first term takes its highest values for modules where a low proportion of students take the exam and therefore the proportion of students that pass the module with respect to the registered students is low and the number of opportunities used to actually take the exam for the first time is high.

The influence of the different factors (Stage, temporal location in the academic year, course, and assigned ECTS value) on the principal components scores was explored. Differences between the different courses at the School for Industrial Engineering was found for the PC2, where two courses scored typically higher: the Industrial Management Engineer course and the Automatism and Industrial Electronics course, where a significant part of the students work and therefore have a higher tendency to use several opportunities before taking an exam. Principal components plots (PC2 versus PC1) were also provided to follow the temporal evolution of the module scores. As an example, the scores obtained for the considered years by the modules of the first stage of the Industrial Engineering course are shown in Figure 1. This kind of plot allows monitoring the evolution, for a given module, of the student behaviour and results and detecting possible difficulties.

4.2 Data-Set *S*

For dataset *S* five variables *MARK_SLC, DURATION, MARK_GRAD, OPP_TAKE_EXAM, NUM_EXAM_PASS* were considered for the principal component analysis based on their correlation matrix. The proportion of variability explained by the first, the first two and the first three components is respectively 55%, 75% and 85%, and the expression of the first three components is:

PC1= 0.37·MARK_SLC + (-0.47)·DURATION + +0.46·MARK_GRAD - 0.45·OPP_TAKE_EXAM- -0.46 NUM_EXAM_PASS (4)

PC2= -0.56 MARK_SLC+ -0.48 DURATION - 0.37·MARK_GRAD -0.54·OPP_TAKE_EXAM + 0.19 NUM_EXAM_PASS (5)

PC3= 0.74 MARK_SLC - 0.06 DURATION - 0.42·MARK_GRAD -0.25 OPP_TAKE_EXAM + 0.46·NUM_EXAM_PASS (6)

As for dataset *M*, the first component is easy to interpret as a global score of the graduated student's success: it consists of a weighted average of all variables, with positive weights for variables that translate positively in terms of the student's results and negative weights for variables for which high values would indicate worst results. The second component is interpreted as the sum of two terms: *MARK_SLC+MARK_GRAD - NUM_EXAM_PASS* and *DURATION + OPP_TAKE_EXAM.*

The weights have been omitted, which reflect on one hand the student's performance (their marks and the number of times they need to take an exam to pass the module) and on the other hand their apprehension before taking an exam (*OPP_TAKE_EXAM*) which have of course an influence on the duration of their studies. The students that score most negatively on *PC2* have achieved good or very marks at the School Leaving Certificate and during their graduate studies but have taken a rather long time to graduate and have used several opportunities before actually taking an exam.

Finally the third component can be seen as the influence of two differences: *MARK_SLC-MARK_GRAD* and *NUM_EXAM_PASS-OPP_TAKE_EXAM*: students that score high in *PC3* are students that have achieved lower marks during their graduate studies than was expected from their School Leaving Certificate and that, although they usually take the first opportunities to take an exam, frequently fail and need to repeat the exam several times to pass the module.

As for dataset *M* in the previous subsection, an exploration of the influence of the factors considered in the dataset on the principal components was carried out. As an example, interesting facts was the influence of the Gender on the *PC3* score. Consider for example the Technical Industrial Engineer course, mention Industrial Chemistry, where approximately half of the graduated students are female (concretely 49 out of 101 individuals in the dataset *S*), consider the lower part of the *PC3* scores that contains 10 % of the students, i.e. the portion of the dataset with *PC3* scores values under the corresponding 10% quartile, only 1 out of the 9 corresponding students is female, while if you consider the 10% upper part, 8 out of the 9 included students are female.

5 CONCLUSIONS

In this paper the main aspects of a statistical study about students' academic behaviour and results at the School for Industrial Engineering in the Technical University of Cartagena are presented. This study was initiated to provide supporting material to the local committees at the university, who are in charge of designing the new curricula and syllabuses as a consequence of the restructuration of the courses in the context of convergence to the 'European Higher Education Area'. Two datasets were considered, one focused on modules and the evolution of associated academic indicators, and the other one focused on graduated students.

This datasets allowed us to explore systematically and confirm (or refute) the existing impressions or empirically gained knowledge of the members of the committees based on their experience as teachers and managers at the university. Additionally, it also allowed identifying a few modules with atypical results and quantifying up to which extent they behaved really differently from the other modules in the same course, and opened thus the door to a possible action from the responsible of the School.

Multivariate analysis techniques like principal component analysis and clustering have been used to understand better the structure of the variability between modules and between students, and permitted to define sensible partitions of the datasets: five groups of modules characteristics were proposed while six profiles for the graduated students were suggested. It is then particularly interesting to check the association of relevant factors with the groups' composition: for example the differences in gender composition between the different students' profiles, or the differences in the groups relative size between the different courses.

ACKNOWLEDGEMENTS

The authors are very grateful to the Vice-Chancellor for European Convergence and Quality Standards Education, *Josefina García-León*, for her constant support; and to the Chief Computing Developer, *José Sánchez-Manzanares* for endless technical help and advice.

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Using ICT to Support e-Learning in Higher Education

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Keywords: e-Learning, Higher Education, Technologies.

Abstract: As e-learning has an established presence in higher education we need to ask the question: How effective is an information and communication technology (ICT), including Learning Management System (LMS) and OpenMeettings synchronous tool, for student learning in high education? This paper collects teacher and student opinions on teaching and learning using ICT, and addresses the following key elements: (i) technological aspects and (ii) methodological aspects. These opinions are compared and analysed to provide also the resources needed for high quality learning using ICT.

1 INTRODUCTION

Information and communication technologies (ICT) have a "powerful" role in academic learning (Ketabchi et al., 2008). Several universities in the world use it on traditional and electronic learning (e-learning). Identification of effective ICT characteristics on offering e-learning courses is an important issue. The purpose of this paper is to provide a case study concerning the current use of ICT for e-learning in higher education. In this course, the Learning Management System is *Moodle* (https://moodle.org) and, for synchronous sessions, the OpenMeetings framework is used (http:// openmeetings.apache.org).

This case study covers student and teacher opinions about ICT aspects of e-learning in an undergraduate degree context (Bologna first study cycle) and addresses the following key elements: (i) technological aspects and (ii) methodological aspects.

With the element (i) it is possible to collect participants' opinion about Moodle and OpenMeetings, in particular, and other ICT elements (video, power points, etc.) in general. Element (ii) collects how participants use Moodle and OpenMeetings, in particular and other ICT elements (video, power points, etc.) in general.

This paper is organized as follows: Section 2 presents the background, while Section 3 presents the method of the survey application; Section 4 presents the results and discussion and, finally, conclusions and future work are briefly outlined in Section 5.

2 BACKGROUND

Although aware that ICT alone does nothing to enhance online pedagogy, advancements in ICT, specially learning management systems such as Moodle, have created remarkable opportunities for higher education to expand the educational process beyond the traditional classroom to include geographically dispersed students. It is important to understand how ICT are being used and how they impact on students and teachers.

2.1 e-Learning

One possible definition for e-learning is: "The use of new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services as well as remote exchanges and collaboration." (EU Commission, 2005). Therefore, the term e-learning is an umbrella concept for the use of technology in various ways to enhance learning. So, this paper presents the ICT involvement considering:

(i) ICT support for e-learning communication. The communication could be synchronous (e.g. chat) and/or asynchronous (e.g. threaded discussions).

(ii) ICT offers media sources, using speech, and video. Besides this, spreadsheets, text and data management are also ICT sources.

(iii) Learning Management Systems (LMS): a software framework that deploys, manage, tracks and report on interactions between learner and content and between the learner and the teacher (EU Commission, 2005).

2.2 Related Work

The work in (Heirdsfield et al., 2011) collects teacher, student and staff perceptions of teaching and learning using Blackboard (http://www.blackboard.com). The impact of Blackboard has been such that technology-mediated instruction is the norm including for on-campus learning. All participants see Blackboard as more than simply a repository of learning resources, and think its interactive features enhanced students learning experience.

(Hrastinski, 2008) presents the limitations and benefits of synchronous and asynchronous e-learning communication. The research discussed therein demonstrates that synchronous and asynchronous activity complements each other. Synchronous activity is used for increased motivation and convergence on meaning. Asynchronous activity is used for increasing reflection and ability to process information.

(Welsh et al., 2003) reviews literature on e-learning and pointed out the future of e-learning, such as (i) growth in synchronous learning; (ii) prevalence of blended solutions; (iii) improved technology and access.

A subset of parameters of the Yi-ShunWang framework was selected to evaluate the eLearning Center at University of Tehran (Ketabchi et al., 2008). These parameters are grouped into (i) content-related (ii) communicative-related (iii) evaluation-related and (iv) LMS-related. The opinion of 3000 students about eCourses (mathematics, physics, chemistry and languages) was collected and the results reveal a low classification for the LMS, which should be replaced by another.

(Kinuthia and Dagada, 2008) presents a study to explore how ICT is being used for teaching and learning purposes and was guided by the following questions: how is ICT being used for teaching and learning purposes? What instructional strategies are employed in the design and delivery of the ICT-integrated content? This study collected data from interviews with educators and instructional at three institutions of higher education in South Africa, in physical and virtual classrooms context. The results indicate that a varietyof tools including software, LMS and print resources are being integrated. There are barriers to e-learning, such as, large class sizes, limited bandwidth, time, and financial limitations. Regardless of this, learners and educators are satisfied with e-learning.

Our work differs from previous since we collect information about i) how participants use ICT elements (video, power points, Moodle, OpenMeetings, etc.) and ii) the participants' opinion about OpenMeetings, i. e. synchronous sessions.

2.3 Course Characterization

The undergraduate degree is offered both on-campus and distance mode. Therefore, some students choose to study in distance mode because of family and/or work commitments, or because they live too far from the campus. As said, the course uses Moodle as a LMS and for asynchronous sessions. Here is where resources are published: video (YouTube or other); power point documents; documents in pdf or spreadsheets; glossary, etc. Forum, Chat and assignments are Moodle features used by teachers and students.

For the synchronous sessions, i. e, web conference, the OpenMeetings (OM) framework is used, using its Moodle's plug-in (https://moodle.org/plugins/view.php?plugin=mod_openmeetings).

All curricular units use OM two hours per week. The teachers had training in Moodle and OM, but students did not. Teachers have autonomy to expose the content as they wish.

3 METHOD

All teachers and students of the undergraduate degree were invited to participate in an online survey. Two surveys, one for each group, were performed based on three criteria. The criteria were the identification of (1) participants' profile, (2) technological aspects and (3) methodological aspects. Using criterion (2) is possible to collect participants' opinion about Moodle and OpenMeetings, in particular, and other ICT elements in general (video, power points, etc.). Criterion (3) collects how participants use Moodle and OpenMeetings, and other ICT elements. The survey's items for criteria (2) and (3) are presented in Section 4.

Considering the results of participants' profile, the average age of teachers is 42 and the age range is 28-52. The average age of students is 39 and the age range is 23-56 years. About half the students from the study cycle are from all country districts apart from the campus one.

100% of students and teachers use Internet and have computers for over 3 years. 52% of students classify as good the way they use the Internet. 48% of students classify as good the way they use a computer. The majority of students (87%) in the current study had broadband internet access at home.

4 RESULTS AND DISCUSSION

4.1 Technological Criterion

There were many commonalities between teachers and student opinions in relation to both positive and negative features of ICT. However, there were also points of difference between the two groups. The following sections present the opinions for each item in the survey. When considered relevant, comments are made for specific items. These comments results from global analysis of the survey, and contact meetings with teachers and students elected by their peers to represent them in the Technical-Scientific and Pedagogic Commission of the course.

Moodle

How do you classify menus presentation in Moodle?

As shows in Figure 1 the majority of students and teachers give good classification, 57% and 63% respectively.

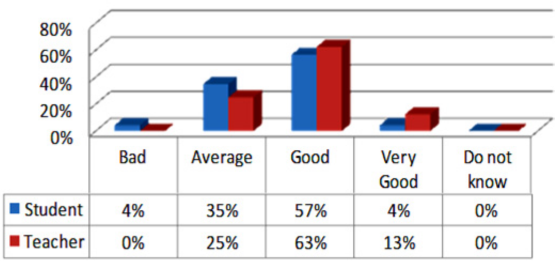


Figure 1: How do you classify menus presentation in Moodle?

How do you classify Moodle forums?

As shows in Figure 2 the majority of students classified as average (52%) and the majority of teachers classified as good (69%). We believe that this difference is because the teachers have more experience and training to use forums. If a forum is very participative, the student can be lost in the set of replies.

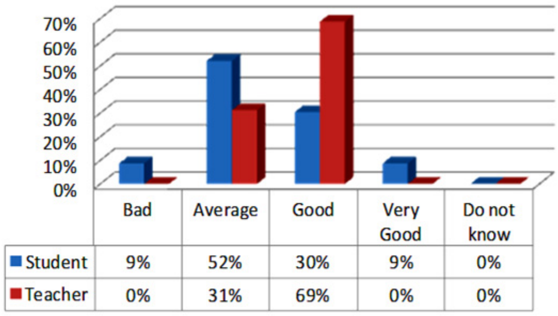


Figure 2: How do you classify Moodle forums?

How do you classify Moodle chat?

As shows in Figure 3, the majority of students and teachers classified as average, 48% and 50% respectively. We believe that this result is related to the difficult to manage the chat and the impossibility to record the information posted in the chat.

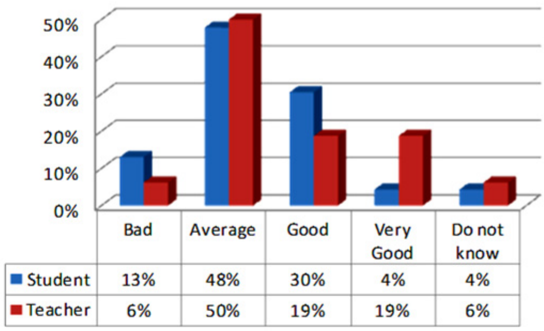


Figure 3: How do you classify Moodle chat?

How do you classify Moodle assignment?

As shows in Figure 4, 43% of students and 75% of teachers classified as good. Notice that 39% of students classified as average. We believe that average and good classification are very close because the students did not have any training to use this element.

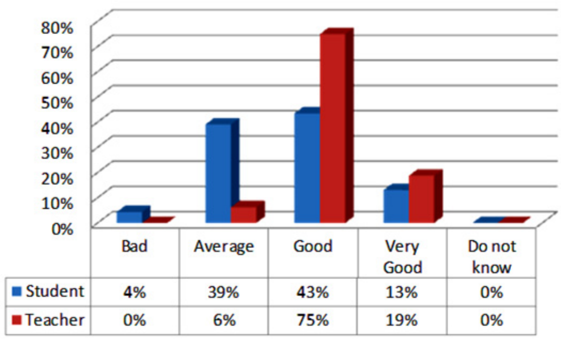


Figure 4: How do you classify Moodle assignment?

How many times did you have trouble using Moodle this semester?

As shows in Figure 5, 39% of students and 63% of teachers had troubles between 1-3 times in the semester. Notice that 17% of students had 10 or more troubles. We believe that this situation occurs specially to students in the beginning of undergraduate degree or with the students with internet access problems. Other strong causes are the use of wireless connection to access the internet, and the simultaneous use of other software applications on the computer.

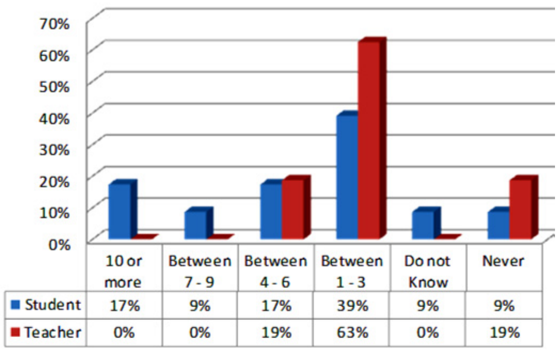


Figure 5: How many times did you have trouble using Moodle this semester?

Finally, considering Moodle's items, students are less satisfied with Moodle than teachers. We believe that this situation is created by the lack of training. Therefore, training sessions for the students are proposed to address this issue.

OpenMeetings

How do you classify the OM audio?

As shows in Figure 6, 22% of students and 50% of teachers classified as good. Notice that 61% of students and 44% of teachers classified as average, and, on the other hand, 9% of students classified very bad and 4% very good. We believe that the worst classification is caused by: (i) internet access; (ii) use of high demanding computational/network resource applications when an OM session is running; (iii) headset (microphone and headphone) is not used.

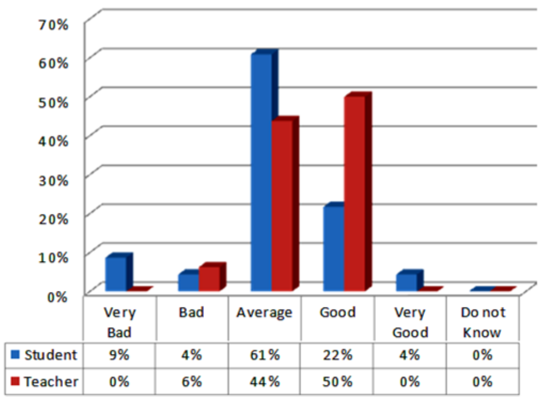


Figure 6: How do you classify OM audio?

How do you classify OM chat?

As shows in Figure 7, 31% of students and 61% of teachers classified as average. Notice that 9% of students and 13% of teachers classified as bad. We believe that this result, as the results regarding Moodle chat, is related to the difficult to manage the chat and the impossibility to record the information posted therein. Moreover, comparing this classification with Moodle chat's classification, the participants classified very bad only on Moodle chat.

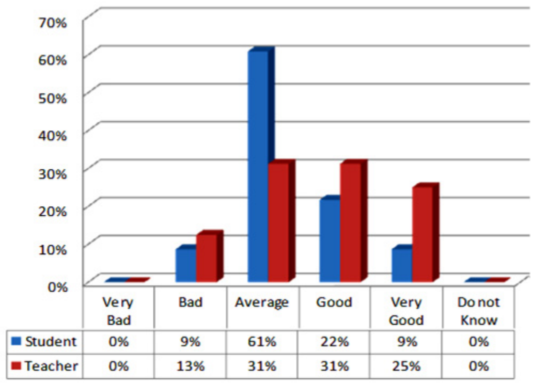


Figure 7: How do you classify OM chat?

How many times did you have trouble using OM this semester?

As shows in Figure 8, 30% of students and 50% of teachers had trouble between 1-3 times in the semester. Notice that 17% of students had 10 or more troubles. We believe that this situation occurs in particular due internet access problems, and, as referenced before, to the use of wireless connections and simultaneous use of other software applications.

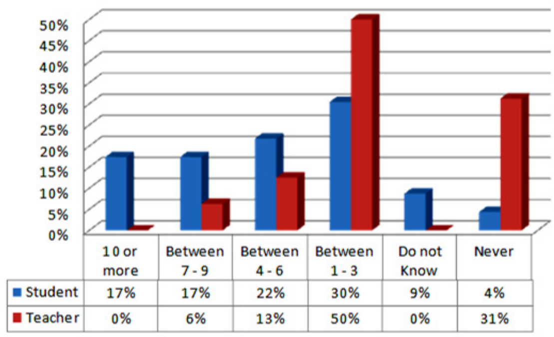
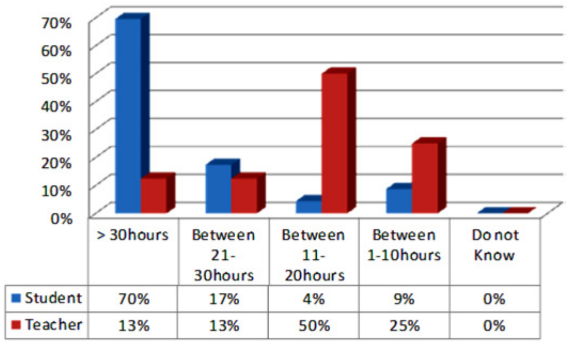


Figure 8: How many times did you have trouble using OM this semester?

4.2 Methodological Criterion

On average, how many hours do you use Moodle per month?

As shows in Figure 9, 70% of students spend more than 30 hours using Moodle, and 50% of teachers spend between 11-20 hours. These results show that students and teachers use Moodle in the e-learning process in a significant way.

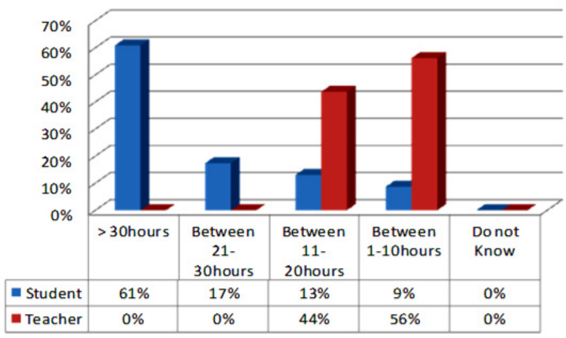


	> 30hours	Between 21-30hours	Between 11-20hours	Between 1-10hours	Do not Know
Student	70%	17%	4%	9%	0%
Teacher	13%	13%	50%	25%	0%

Figure 9 : How many hours do you use Moodle per month?

On average, how many hours do you use OM per month?

As shows in Figure 10, 61% of students spend more than 30 hours using OM, and 44% of teachers spend between 11-20 hours. When comparing this result with Moodle results we can conclude than the use of Moodle is correlated to OM use, i. e. 88% of students use Moodle and OM more than 30 hours. The same analysis can be made for teachers, i.e., 88% of teachers use Moodle and OM between 11-20 hours.

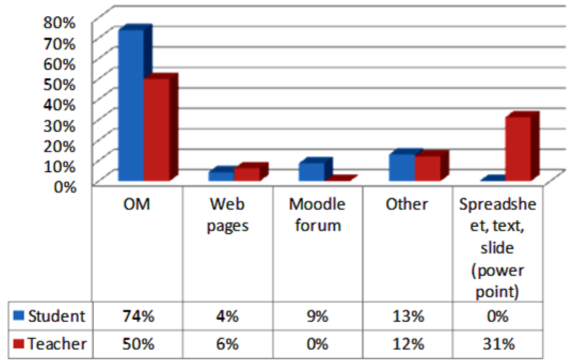


	> 30hours	Between 21-30hours	Between 11-20hours	Between 1-10hours	Do not Know
Student	61%	17%	13%	9%	0%
Teacher	0%	0%	44%	56%	0%

Figure 10: How many hours do you use OM per month?

(Student) What ICT aspect contributed most to your learning? Or (teacher) What ICT aspect contributed most to your knowledge transfer?

As shows in Figure 11, 74% of students and 50% of teachers select OM as the aspect that contributes more. OM is used a lot by the teachers to guide the students in the learning process and to clarify students' doubts.

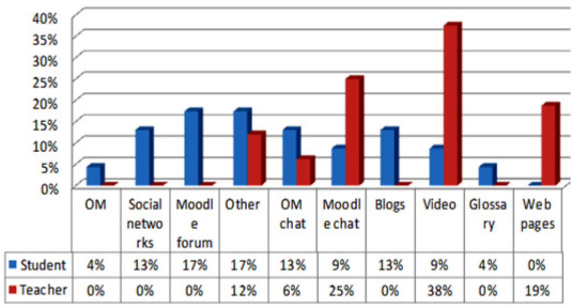


	OM	Web pages	Moodle forum	Other	Spreadsheet, text, slide (power point)
Student	74%	4%	9%	13%	0%
Teacher	50%	6%	0%	12%	31%

Figure 11: What ICT aspect contributed most/higher? to your learning? Or What ICT aspect contributed most to your knowledge transfer?

(Student) What ICT aspect contributed less/few to your learning? Or (teacher) What ICT aspect contributed most to your knowledge transfer?

As shows in Figure 12, 17% of students chose Moodle forum as the aspect that contributes less. For 38% of teachers, video is the aspect less interesting for knowledge transfer. This is clearly in opposition to student's opinion (9%), and we believe that the teacher opinion is related to the lack of training. So, video training sessions for the teachers is proposed to address this issue.



	OM	Social networks	Moodle forum	Other	OM chat	Moodle chat	Blogs	Video	Glossary	Web pages
Student	4%	13%	17%	17%	13%	9%	13%	9%	4%	0%
Teacher	0%	0%	0%	12%	6%	25%	0%	38%	0%	19%

Figure 12: What ICT aspect contributed less to your learning? Or What ICT aspect contributed less to your knowledge transfer?

5 CONCLUSIONS

The results of this case study pointed out the importance of synchronous sessions (OM sessions) to the students and teachers, supporting (Welsh et al., 2003) conclusions. Based on this, we will propose to improve teachers' skills in order to manage synchronous sessions.

In a nutshell, the positive aspects of ICT in e-learning context are:

-Students have access to resources anywhere, anytime;

- High degree of flexibility and individualisation;

- The positive attitude and involvement of teachers in relation to the use of ICT.

The negative aspects of ICT in e-learning context are:

- Low quality audio;

- Difficulty to clarify doubts in a timely manner when asynchronous mode is used;

- Technical problems arising from lack of training and knowledge;

- Too much resources for study and sometimes not fully organized.

The recommendations pointed out by the participants are:

- Teachers must have ICT training, e. g. video, spreadsheets, database, author tools, etc;

- Teachers must ensure the existence of the right conditions before the beginning of OM sessions;

- Improve audio quality in synchronous sessions;

- More training and support for Moodle users (students and teachers);

- Sessions held in OM must be recorded simultaneously with chat, sound and image;

- Files (power point, pdf) must be loaded more quickly in synchronous sessions;

- Avoid using video streaming in synchronous sessions, to avoid audio problems;

- Teachers should use the same "way" to publish the resources on Moodle (topics, etc.);

- Avoid using the forum to post messages of gratitude (Sometimes, 20 "thank you" posts are received that origin time wasting).

Finally, the results of this survey corroborates the strategies defined by the EU Commission (EU Commission, 2005) which focus on issues as the training of teachers, and increasing the students' use of e-learning as well as their ICT skills. Moreover, demonstrates the students' high consideration to synchronous mode sessions.

For future work, we plan to assess the organizational issue, namely the technical support. Technical support is indeed a very important strength in relation to the use of ICT in e-learning context.

ACKNOWLEDGEMENTS

The authors wish to thank students and teachers for their helpful and invaluable collaboration.

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Scaling Software Experiments to the Thousands

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Keywords: Massive Open Online Courses, Online Experimentation Platform, Software Engineering, Operating Systems, InstantLab, Windows.

Abstract: InstantLab is our online experimentation platform that is used for hosting exercises and experiments for operating systems and software engineering courses at HPI. In this paper, we discuss challenges and solutions for scaling InstantLab to provide experiment infrastructure for thousands of users in MOOC scenarios. We present InstantLabs XCloud architecture - a combination of a privat cloud resources at HPI combined with public cloud infrastructures via ”cloudbursting”. This way, we can provide specialized experiments using VM co-location and heterogeneous compute devices (such as GPGPU) that are not possible on public cloud infrastructures. Additionally, we discuss challenges and solutions dealing with embedding of special hardware, providing experiment feedback and managing access control. We propose trust-based access control as a way to handle resource management in MOOC settings.

1 INTRODUCTION

Knowledge acquisition has never had it better: While our ancestors had to buy very expensive books, we can look up virtually any information on the internet. Universities follow that trend by making their teaching materials available online: Lectures can be streamed and downloaded from platforms like *iTunes U*. Websites like *Coursera* and *Udacity* provide complete courses with reading materials, video lectures and quizzes - sometimes also run directly by universities (e.g. *Stanford Online* or *openHPI*). However, educational resources should not be limited to passive material: 10 years of experience in teaching operating systems courses to undergraduate students at HPI have shown us that actual hands-on experience in computer science is irreplaceable.

InstantLab at HPI. InstantLab a web platform that is used in our undergraduate curriculum to provide operating systems experiments for student exercises at minimum setup and administration overhead. InstantLab uses virtualization technology to address the problem of ever-changing system configurations: experiments in InstantLab are provided in pre-packaged containers. These containers can be deployed to a cloud infrastructure and contain virtual machine images and setup instructions to provide the exact execution environment required by the experiment. InstantLab's core component is a web application, through which users can instantiate and conduct experiments. The running instances of these experiments can be accessed and controlled through a terminal connection, which is set up from within the users web browser (see figures 1, 2).

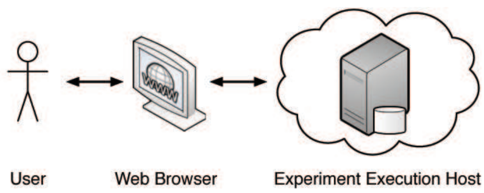

Figure 1: Browser-based access to experiments.

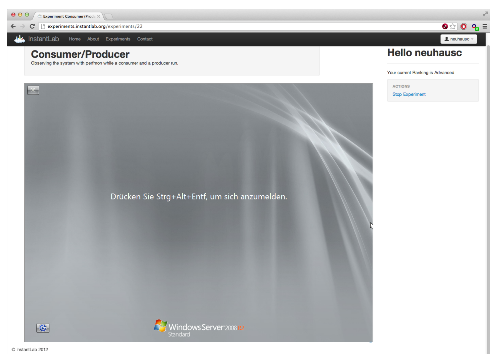

Figure 2: InstantLab: Live Experiments in the Browser.

Over several terms of teaching operating systems courses, InstantLab has proven to be a helpful tool: it allows us to offer various software experiments with very little setup work, ranging from elaborate kernel-debugging exercises to demonstrations of historic operating systems (e.g. Minix, VMS) to more general software engineering exercises.

2 SCALING TO THE THOUSANDS

While InstantLab is used in teaching in our undergraduate classes with great success, we aim to bring this level of hands-on experience and practical exercises to massive open online-courses (MOOCs). This is where it is needed the most: Students at regular universities usually have access to university-provided hardware resources. Students of online courses however come from diverse backgrounds and are scattered all over the world – the only equipment that can be assumed to be available to the participants is a web browser. In this section, we review state of the art of MOOCs and software experiments and identify the challenges that lay ahead.

2.1 State of the Art

Massive open online courses currently enjoy a surge of popularity. Over the past few years numerous web platforms have been created (e.g. Coursera, Udacity, edX, Khan Academy, Stanford Online, openHPI, iversity). A range of Software-as-a-Service products (e.g. Instructure Canvas) and software frameworks (e.g. *lernanta*[1], *Apereo OAE*[2]) are being developed to provide the technical foundation for MOOCs.

In learning theory, the usefulness and importance of learning from experience is an acknowledged fact (see (Grünewald et al., 2013; Kolb et al., 1984)). Consequently, most MOOC platforms address the need for assignments that complement the teaching material and provide feedback to the learner. The most basic form assignments are multiple choice quizzes, which are often embedded into video lectures. They can be automatically evaluated to provide immediate feedback, but the complexity of multiple choice assignments is limited. Extended assignments such as calculations or programming exercises are usually assessed by submitting calculation results or programming language instructions which are checked for correctness. The most sophisticated kind of test allows the upload of entire computer programs that are evaluated by the platform. An approach for automatically giving detailed feedback for programming assignments have been proposed (Singh et al., 2013). Another approach is to conduct practical assignments on students computers. However, this approach faces problems due to the heterogeneity of the students individual computers and makes troubleshooting a tedious task (Christian Willems, 2013).

The current generation of MOOC platforms is well-suited for the presentation of teaching material. On the other hand, the possibilities for hands-on experiments leave a lot to be desired, as assignments are essentially **non-interactive**: Students receive instructions (e.g. writing a computer program) and submit their work (e.g. source code, calculation results) upon completion. This prohibits an iterative test-and-improve cycle of software development and limits the complexity of assignments. Consequently, **observational assignments** (e.g. monitoring software activity) are also poorly represented. In addition, the completion of the assignments often requires **installation of specialized software** (e.g. software developer tools) that is difficult to set up and potentially not available to all participants.

2.2 Challenges and Chances

In this paper we provide an architecture for flexible and interactive software experiments for massive open online courses. We build on our experiences with InstantLab at HPI using pre-packaged software experiments that are executed in virtual machines and present an architecture that leverages public cloud infrastructure resources to cope with the high user load. However, offering live software experiments at MOOC-typical scale is fundamentally different from a classroom scenario: On one hand, the massive scale poses new challenges that have to be met. On the other hand, the large number of participants offers new chances of to improve education and the platform itself. In this paper, we address the following issues:

GPU and Accelerator Hardware. Embedding special hardware resources into cloud-hosted experiments is a difficult task: We show how new virtualization technology can assign physical hardware to different users and employ a compilation-simulation-execution pipeline to use scarce physical hardware resources only for tested and correct user programs (see section 3.2).

Experiment Monitoring. Learning from experience with practical experiments is only possible when feedback on a students performance is provided.

[1] https://github.com/p2pu/lernanta/
[2] http://www.oaeproject.org/

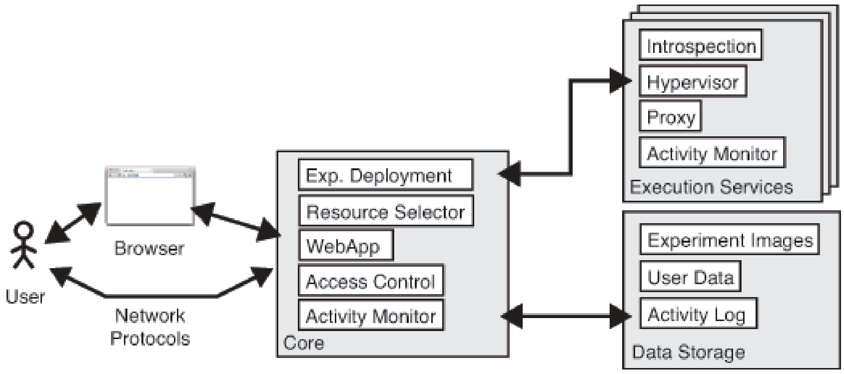

Figure 3: XCloud architecture.

To gather the required information, we propose methods for experiment monitoring by using virtual machine introspection to monitor students performance during assignments (see section 4.)

Security and Access Control. Access to expensive experiment resources should only be granted to advanced and earnest participants of a course. Traditional access control mechanisms fall short as they require manual privilege assignment. Instead, we propose a trust-based access control scheme to automatically govern access to experiment resources (see section 5).

3 XCloud ARCHITECTURE

To be able to set up, manage and maintain complex experiment testbeds of heterogeneous hardware on cloud infrastructure we propose the XCloud architecture (see figure 3). The main component of the architecture is the **core**, which hosts a web application. Users can connect to it using a web browser (to start experiments and access virtual desktop screens) or arbitrary network protocols (e.g.SSH). The core is also responsible for selecting appropriate hardware resources (resource selector) and deploying experiments to **execution services**: These services provide the hardware resources for running experiments. User activity in the system is gathered through **activity monitors** and virtual machine **introspection**. This activity data (required for trust-based access control, see section 5) is stored in the **activity log** within the **data storage** service, which also holds virtual machine disk images for experiments and individual user data generated during experiments.

The XCloud model consists of two major components. First, we extend the IaaS concept with an explicit notion of a (virtualized) network interconnect within the cloud. In addition, we distinguish among different types of processing units those may have different processor architectures such as x64 or Itanium or they may act as co-processors, such as GPUs (Nvidia Tesla, K20, Intel Xeon Phi). Our current implementation of xIaaS is based on HPs Converged Cloud hosted within the FutureSOC-Lab at Hasso Plattner Institute.

Clients may access certain components of the xIaaS infrastructure separately just as they would access an IaaS cloud however, typically the xIaaS infrastructure is treated as a big multicomputer with compute nodes, accelerator nodes, and an interconnection network. Parallel computing workloads rely on topology information provided by our xIaaS implementation. For experiments that use the platform-as-a-service paradigm the user's client may receive communication endpoints for additional services. For effective access control, the connection endpoints of an experiment are grouped and governed be a trust-based access control scheme (see section 5). Those services are not restricted to the web service protocol they may open remote display connections (RDP) to virtual machines running certain OSes under test, or they may directly connect to the XCloud interconnect using protocols such as MPI (message passing interface). Connecting remotely to systems under test is crucial if it comes to kernel debugging or running certain OS experiments that require monitoring a VMs boot phase. Connecting directly to XClouds interconnect is required when running certain (master-worker-style) parallel applications that need to utilize the heterogeneous compute resources of XCloud. Figure 3 gives an overview over XCloud architecture.

3.1 xIaaS

We extend the current IaaS service abstraction to xIaaS components (4). A xIaaS-component template is described by the following properties:

Network Interface. Just like an IaaS-service, a xI-

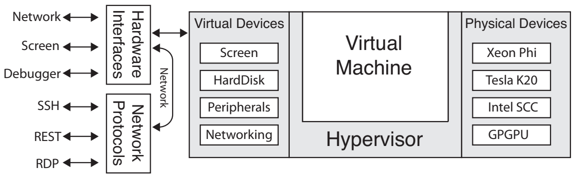

Figure 4: xIaaS Component.

aaS component is accessible through the network services which are provided by its operating system.

Hardware Interface. This interface describes connections to arbitrary ports of the virtual hardware (such as screen connection, Ethernet, USB, debugger connections, etc.). These connections can be made available to end users through tunneling protocols. These hardware interface can also be connected to corresponding hardware interfaces of other xIaaS components.

Accelerator Hardware. xIaaS components can be configured to include specialized accelerator hardware. Deployment mechanisms use a hardware description to deploy these components to specialized hardware which supports these devices.

The ability to connect the hardware interfaces of several xIaaS-Components allow the creation of virtual infrastructures within xCloud. This enables experiments setups such as kernel debugging where two connected machines (e.g. serial cable) are required.

3.2 Virtualization of Accelerator Hardware

The current trends in hardware developments lead to an increasing amount of variation, both in hardware characteristics and hardware configurations. Instead of homogeneous general purpose processors computers will be equipped with a variety of special accelerators that need to be orchestrated to run a given algorithm in the most efficient way. The first type of accelerators that gained a great popularity are GPU Compute Devices. Current versions support a wide variety of applications and programming styles and the literature is full of success stories of algorithms that gain drastic performance benefits from GPU acceleration. Intel, joining this trend, introduced a new type of accelerators with its Intel's Xeon Phi accelerator boards which are special in the sense of being fully x86-compatible. Caused by the popularity and benefits of accelerators, especially for performance-hungry applications, a number of cloud-hosters like Amazon, Nimbix, and peer1hosting, chose to add accelerator-based Cloud-solutions to their portfolio. Currently, these solutions are basically IaaS products that allow exclusive direct access to physical GPUs.

For real GPU Virtualization, four characteristics are to be considered: performance, fidelity, multiplexing, and interposition. (Dowty and Sugerman, 2009) Performance indicates the execution speed and depends largly on the overhead introduced by the virtualization mechanism. Fidelity is a measure of the number of features of the physical device that are supported by the virtualized device. Multiplexing indicates if multiple VMs share the same physical GPU. Interposition allows to mediate access between a virtual machine and the physical hardware. This enables features like VM migration, VM hibernation, and fault-tolerant execution.

When it comes to studying accelerator computing it is most crucial to learn about performance characteristics and performance optimization techniques of accelerators ((Kirk and mei Hwu, 2010),(Feinbube et al., 2010)). Consequently, we need to make sure that we can guarantee a representative performance (e.g. a small constant overhead for the virtualization) and a high fidelity. Interposition, on the other hand is not as important in our scenario, because student experiments do not require a highly reliable execution. The amount of multiplexing that is required depends largely on the amount of accelerators that we have in possession and the number students that we want to allow to concurrently work with our MOOC exercise system at a given point in time.

If we can make sure that we only have one student per accelerator we can provide them with exclusive access to the accelerator hardware. Although this would guarantee the best programming experience for the students, it would require us to either restrict the number of students or dynamically increasing the number of accelerators by relying on other cloud offerings resulting in additional costs. Another problematic case is, when the desired accelerator is not provided by any cloud hoster at all, but only available in small numbers in our lab. The extreme would be a very large number of students accessing a very small amount of accelerators.Such a scenario would be beyond the feasibility of virtualization and consolidation. The only option would be to use a job queue and line up their task submissions for the accelerator. Since only one job would be executed at a time, the resulting execution performance and fidelity would be very realistic. The user experience, on the other hand, would be rather limited, especially since even debugging becomes an issue. In (Tröger et al., 2008) we describe some techniques to improve the user experience and performance of MOOCs where many students are working with single unique physical experiments.

From a cloud standpoint the most interesting part lies somewhere in between: having a fair amount of students per accelerator.In those cases virtualization techniques provide a means to allow multiple users to work concurrently on the same physical hardware without interfering with each other. Modern GPUs support some features required for this: namely separate execution contexts and the ability to run concurrent kernels exclusively on dedicated GPU streaming processors. (NVIDIA Corporation, 2012) Ravi et al. build on this to implement a GPU virtualization framework for cloud environments. (Ravi et al., 2011) In addition to this, vendors of virtualization solutions like VMware (Dowty and Sugerman, 2009) and Xen (Dalton et al., 2009) study architectures to allow for performant GPU virtualization.

4 RECORDING USER ACTIVITY

In a MOOC scenario, personal tutoring and feedback are difficult due to high numbers and participants and the distance between teachers and students. Consequently, automatic methods are required for providing feedback on assignments, monitoring learning progress and grading. In InstantLab, there is the additional challenge of dividing up limited resources for software experiments among users. The challenge lies in “getting to know” students through the available means of the platform. We propose two monitoring techniques to gather knowledge about MOOC participants: On the web platform, we record a students activity to gain information about their progress within a teaching curriculum. For detailed feedback and grading of assignments, we propose virtual machines introspection techniques to monitor activity within active software experiments.

Activity Monitoring on the Web Platform. The available experiment resources should primarily assigned to students who have a serious interest in the course. A good indicator for this is the activity and participation that students exhibit over the course to follow the curriculum. In a MOOC, student activity can be observed and recorded by monitoring a users activity with the web platform. Event such as logins, watching video lectures and starting, finishing or aborting software experiments are recorded in the *activity log* (see figure 3) and can later be used to for *trust-based access control*.

Experiment Monitoring. The benefit of running experiments in virtual machines on the MOOC platform is the possibility to monitor activity during these experiments: This way, feedback is not solely limited to the outcome of an experiment, but can also incorporate observations during the assignment. These observations can also be used to limit abuse of the provided resources (see section “Security”).

Monitoring of students software experiments, should be transparent, efficient and tamper-resistant. Embedding monitoring programs into the experiment VMs falls short of these requirements. Instead, we implement the experiment monitoring at the level of the VM hypervisor, a technique known as *virtual machine introspection* (VMI) (Pfoh et al., 2009). Placing the monitoring in the hypervisor requires no alteration of the experiment templates by and is transparent to the VM execution. At the same time, the isolation of the VM hypervisor protects the monitoring from tampering. Typically, VMI has to bridge the *semantic gap* (Chen and Noble, 2001): By execution monitoring functions in the hypervisor, abstractions of the target OS are not available. In our approach, the used OSs are known to the platform operator – the semantic gap can therefore be bridged by knowledge about the used OS. Software support for VMI is available for popular hypervisors, such as *LibVMI*[3] for Xen and KVM and *VProbes*[4] for VMWare products.

Virtual machine introspection make a wide variety of information available for monitoring of software experiments:.The prime for monitoring event are privileged operations of the guest OS that have to be emulated (e.g. hardware access, system calls). Additional monitoring events can be generated by manipulation of the guest memory and virtualized hardware state (e.g. marking memory regions as non-writeable). Further information can be extracted from monitoring a VMs network communication an scanning its memory.

5 SECURITY

Offering live software experiments to a broad audience creates challenges for the security of such a platform. In this section, we address two aspects: We outline the security threats of the scenario and propose virtual machine introspection methods as a mitigation strategy. Secondly, we show how automatic resource management can be achieved using a trust-based access control scheme.

[3]https://code.google.com/p/vmitools/

[4]http://www.vmware.com/products/beta/ws/vprobes_reference.pdf

Security for Live Software Experiments. Offering users access to virtual machines creates a new security challenge which is not usually present on other platforms: Malicious users could abuse the provided resources for other purposes than the intended software experiments – and therefore violate the *integrity of the system*. At the same time, security mechanisms should not limit users in completing their assigments.

As a solution, we propose *virtual machine introspection* mechanisms to monitor live software experiments to detect misuse of the provided virtual machines (as proposed in (Garfinkel et al., 2003)). To detect abuse, we maintain a *blacklist* of actions or system states that should not be permitted within VMs associated with an experiment. VMI technology is then used to monitor the VM and detect blacklisted actions or states. If a violation is detected the system can either warn the user first and display the violation that occurred. If the violations persist, the experiment is terminated and the associated VM is shut down.

Running software experiments in virtual machines at a large scale is a resource-intensive task. At the same time, the amount of available resources is limited: While cloud scaleout can cover high workloads, budget constraints may limit the total amount of usable resources. Moreover, most specialized hardware can only be used exclusively – limiting the number of simultaneous experiments. At the same time, resource constraints should not get in the way of the learning process.

Therefore, a diligent resource management scheme for access privileges to experiment resources is required for distributing the available resources among the users of the platform. This scheme should fulfill the following properties:

Self-mangement. Open online courses typically have large numbers of users who are not known to the operator. Due to the lack of knowledge about users and administrative overhead, it is not practical to assign user privileges manually. Instead, the scheme should be able to assign access privileges automatically.

Abuse Prevention. Unintended activity and abuse of the provided resources should be detected and prevented.

To achieve such a resource management scheme, we control access to experiment resources using *Trust-based Access Control*. We review foundations of the concept in section 5.1 and show how we apply it to the MOOC scenario 5.1.

5.1 Trust-based Access Control

Trust-based access control (TBAC) is a dynamic access control scheme that builds upon the notions of *reputation* and *trust* (Josang et al., 2007): Reputation information characterizes an actors standing in a system. Based on this information, trust levels assigned to actors indicate a subjective level confidence that the actor will behave in a desired way in the future. Trust levels can be indicated on a numerical scale such as a values $x \in [0; 1]$ where a high number indicates a high level of confidence. These levels are subjective values and reflect an actors individual confidence in another actor in the system. A trust level can be calculated based on own experience of past behavior of an actor or reputation information which can be obtained from a central authority (centralized system) or from other actors in the system (federated system).

Trust-based access control (TBAC) is as a dynamic extension of traditional access control models (mandatory, discretionary, role-based) (Boursas, 2009; Chakraborty and Ray, 2006; Dimmock et al., 2004): Access rules in security policies can be specified using a minimal trust-level that is required for access to a certain resource. Access requests are granted for actors whose trust level is greater or equal to the specified minimal trust level and declined otherwise.TBAC has been proposed for a range of application such as access control in pervasive computing devices (Almenárez et al., 2005) or P2P-networks (Tran et al., 2005). TBAC is used on the popular website *Stackoverflow* to determine user privileges.

TBAC for Open Online Courses. The purpose of the trust-based access control mechanism is to govern user access to the limited experiment resources in open online course systems. Instead of creating access policies that contain user-specific rules, access to experiment resources is based on a users trust level. In order to build these trust levels, a MOOC system cannot rely on external sources of reputation information for its users. To make the TBAC scheme work autonomously, we calculate trust levels based on the behavior and actions of a user within the MOOC platform. The only requirement is therefore to recognize users in the system, which we achieve through an OpenID login.

System Overview. An overview of our approach a TBAC system for online courses is given in figure 5. **Activity Monitors** are responsible for collecting user activity on the course platform (e.g. starting / aborting / completing experiments and lessons). Data about user activity is stored in the **Activity Log**. When access to an experiments resource is requested,

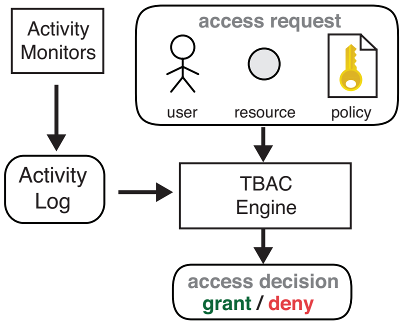

Figure 5: Trust-based Access Control System.

the request is passed to the **TBAC Engine**. This component calculates a users trust level based on his previous behavior in the the Activity Log. Access is granted if the resulting trust level satisfies the experiment policy.

Properties of Online Courses. The calculation of trust levels for online course systems can make use of the properties of a structured curriculum: Online courses usually start out with introductory lessons, which are easy to comprehend. Similarly, practical exercises in introductory lessons will most likely not require specialized hardware and are easy to implement. As the course progresses, the contents of teaching become demanding. Accordingly the accompanying experiments most likely require more complex resources. As the skill level of students during the course increases, so do the resource requirements of practical experiments. As the latter experiments are more resource-intensive, the should only be accessible to skilled students. Therefore, we group experiments in four different stages which have to be completed during a curriculum.

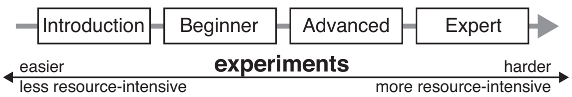

Figure 6: Course curriculum: Difficulty Stages.

Trust Levels. We make use of these stages by employing a staggered approach for calculating trust levels: Entering a new stage (see figure 6) require a user to reach a required trust level in the previous stage. These levels in the system are expressed as a number $t \in [0,1]$. Every user who registers on the online course platform is initially assigned a trust level of $t = 0$. The trust levels that can be reached in every stage and are required for the next are given in the following table:

This scheme ensures that the resource-intensive experiments of the advanced and expert units can only be accessed by users who built according skills in the previous units. By its design, it addresses two specific issues of trust mechanisms: This scheme ensures that effort in every stage of the curriculum is required in order to proceed to more advanced experiments. This way, it prevents unskilled user from completing numerous trivial experiments in the *Introduction* stage order to skip to advanced stages of the curriculum. Furthermore, as a users trust level in the system does not fall below zero, there is no way to circumvent the system by changing identities (i.e. signing up with a new account).

Table 1: Required and reachable trust levels different stages.

Stage	Required level	Reachable level
Introduction	-	0.25
Beginner	0.2	0.5
Advanced	0.4	0.75
Expert	0.7	1

6 SUMMARY

Massive Open Online Courses enjoy great popularity and are used by millions of users worldwide. However, the possibilities for practical assignments and hands-on exercise are mostly limited to simple quizzes. In this paper we present our vision for embedding live software experiments into open online courses: We introduce *InstantLab* – a platform for running software experiments on cloud infrastructure and making them accessible through a browser-based remote desktop connection. To truly scale this approach to thousands of users, several challenges have to be met: We address the problem of embedding specialized accelerator hardware into virtualized experiments. As experiment resources are limited, they should be protected from abuse and assigned to users with an earnest learning intent. We employ an automatic resource assignment based on trust levels which are derived from users activities on the platform. As practical experiments requires detailed feedback on the students action to be effective: We draw information from runtime virtual machine introspection to provide detailed feedback about assignments during and after experiments.

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SPECIAL SESSION ON WELL-BEING LITERACY THROUGH MULTIMEDIA EDUCATION FOR VULNERABLE POPULATIONS

FULL PAPERS

Youtube How-to-Videos (HtV)

A Well-being Literacy Tool for Promoting Community Integration in Persons with Disability

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Keywords: Well-being Literacy, Vulnerable Populations, Multimedia Health Education, Youtube as a Social Network, Self-management Skills, Community Integration.

Abstract: Social media's power to connect and educate those with chronic conditions opens new avenues for improving patient self-management. Recent studies have reported increased condition knowledge, patient satisfaction, and compliance with treatment following social media involvement. A 5-year, consumer-focused training project conducted at the Rehabilitation Research and Training Center on Spinal Cord Injury aims to promote self-management skills in persons with SCI in areas of skin care, cardiometabolic risk reduction, and obesity prevention. The training framework incorporates a YouTube-based, shared video social network that connects participants with community-based resources necessary to achieve independence, stability, and community integration. It is anticipated that findings from the project will increase well-being literacy in individuals with SCI and enable them to self-manage health to function more independently in their daily lives and integrating back into the community.

1 INTRODUCTION: HISTORY OF SOCIAL MEDIA IN HEALTH CARE

Social media has accumulated a powerful history of promoting and illustrating various aspects of medical self-management (Agenda, 2013). In recent years, social media has blossomed to include sites such as Facebook (2004), Twitter (2006), and Tumblr (2007) (Shontell, 2012). A Pew Research Report from August 2013 states that 72% of online adults utilize social networking (Brenner, 2013). The popularity of such sites has driven national organizations, including the American Diabetes Association and the Veterans Health Administration, to advertise links to Facebook and Twitter on their homepages to connect and educate online visitors (American Diabetes Association, 2013; Veterans Health Administration, 2013).

In 2012, Goldstein, et al. of the National Kidney Disease Education Program (NKDEP) reported successful use of social media to promote education and health literacy in chronic kidney disease patients. Over the course of one year, NKDEP's Facebook page, *Make the Kidney Connection*, garnered 3500 "likes," while NKDEP's Twitter handle gained 375 followers. Facebook was found to be one of the top 15 referrers to the NKDEP education webpage in 2012, thus exemplifying successful social media promotion of healthcare education (Goldstein et al., 2013).

Similarly a 2013 study by Van der Ejik et al., analyzed the use of Online Health Communities (OHCs) in patient education and connections with clinicians. The research presented case examples in the Netherlands of a nationwide online Parkinson community available to all interested in Parkinson Disease and the ParkinsonNet community, a closed professional network of both Parkinson patients and providers. Over a 12-month period, 54% of both Parkinson community members and ParkinsonNet users posted comments or new content. Implementation of OHCs and Personal Health

Communities (PHCs: composed of a patient, health care providers, and caregivers) in clinics were associated with four improvements in care: improved sharing of knowledge and skill for health care providers, smoother collaboration throughout medical networks, well-supported patient self-management, and the success of patient-focused care. Such improvements could increase patient empowerment and support more successful clinical outcomes (Van der Ejik, 2013). OHCs, such as ParkinsonNet or online SCI communities, have significant potential to improve patient self-management.

2 HEALTH, WELL-BEING LITERACY, AND COMMUNITY INTEGRATION

Health literacy as a foundation for individual and societal well-being literacy has the potential greatly increase the effectiveness of medical treatments. A 2006 report by Kutner et al. analyzed the health literacy of American adults in 2003. The researchers presented 19,000 American adults with 28 activities to measure literacy in “clinical, prevention, and navigation of the health care system” based on literacy scales: a prose literacy scale, a document literacy scale, and a quantitative scale. Participants’ literacy was rated “Below Basic,” “Basic,” “Intermediate,” or “Proficient.” Of the responders, 53% were scored as “Intermediate” in their health literacy while 12% were rated “Proficient.” A significant proportion scored “Basic” (22%) or “Below Basic” (14%) in health literacy. A large percentage of all respondents, regardless of health literacy score, accessed the Internet to obtain health information. Twenty-percent of those with “Below Basic” scores, 42% with “Basic” scores, 67% with “Intermediate” scores, and 85% of respondents with “Proficient” score reported using the Internet to access information about health (Kutner, 2006). Given this information, the use of the Internet, and social media in particular, to increase the health literacy of American adults is a very viable option and one that is furthered by the presented in this publication concerning the work of the Well-being Literacy via Multimedia Education and Psychosocial Research Program.

The Well-being Literacy via Multimedia Education and Psychosocial Research Program (WeLL) is “centered on promoting everyday life skills using evidence-based approaches in health and psychosocial sciences” (Libin, 2013). The purpose of the WeLL program is to apply psychosocial research to improve health literacy through new technology, media, social networks, and artificial intelligence. The term *HtV* (How-To-Videos) was proposed in the course of developing multimedia health education for persons with the Spinal Cord Injury (SCI) as a social network platform for building the self-management skills for persons with Spinal Cord Injury (SCI) (Schladen, Libin, Ljungberg, Tsai, & Groah, 2011) HtV serve as the basis for a social network platform for building the self-management skills in Persons with Diabilities (PWD) relevant to coping with daily challenges.

2.1 YouTube and SCI

With the inception of free video sharing on-line via the YouTube network in 2005, opportunities for self-education increased enormously. YouTube is a popular on-line video community where viewers discover, watch, and share videos that they have created. The online network provides an international forum for people to connect and share knowledge and information. In September 2013, YouTube reported over 1 billion unique visitors per month (Statistics. *YouTube*, 2013). According to a 2013 Pew Research Study, 31% of American adults uploaded videos online as compared to 14% in 2009. Similarly, 78% of American adults watch or download videos today as compared to 69% of internet users in 2009 ((Purcell et al., 2013). Such a popular and growing forum provides an opportunity to present videos to empower persons with SCI and other disabilities.

The Rehabilitation Research and Training Center (RRTC) on Spinal Cord Injury developed “How-to” videos (HtVs), short videos demonstrating SCI life skills, and made them freely available on YouTube (http://www.youtube.com) as part of a consumer-focused training program. HtVs are offered on YouTube as an empowering tool for self-management of physical tasks to increase independence after SCI or other disabling conditions. The following study investigates the utilization of How-to-Videos by patients, therapists, and communities.

2.2 Purpose of On-line Education Media for People with SCI

The innovation of an online video social network like YouTube supports disability self-management in SCI in two fundamental ways. Video social media engage persons with SCI in the development of highly context-specific enacted knowledge that aggregates over time to form an accessible record, a "library" of disability-specific self-management skills. Freely available social media can also function as an ad hoc consumer-oriented program that works with and for persons with SCI as they self-advocate with health care professionals, researchers, or community advocates. Disability self-management can be broadly defined as the ability to successfully cope with consequences of chronic health conditions (Bodenheimer et al., 2010; Libin, 2008). As persons gain experiences in living with disability their mastery of self-management grows. Studies have shown that people who have long experience of living with disability demonstrate higher levels of self-management skills in their daily lives. For instance, mobility and higher physical activity are associated with effective self-management in persons with chronic SCI but not in newly injured individuals (Libin et al., 2010).

In our approach, the use of interactive technology is conceptualized as a self-management tool (Libin, 2006; Libin, 2001; Libin, 2006) for persons with life-long disabilities such as SCI. It builds upon foundations laid by SCI peer mentoring and the patient navigation models (Ljungberg et al., 2010). Peer mentors are individuals with SCI who provide emotional support and education to persons with newly acquired SCI. They use widely accepted techniques such as peer-to-peer focused communication based on sharing one's own everyday experiences. Patient navigators are broadly defined as individuals who are from the patient's community and have accumulated specialized knowledge regarding specific health conditions. An analysis of SCI-specific education videos posted to YouTube follows.

2.2.1 Research Methodology

SCI therapists and consumers with chronic SCI, together with the RRTC team, developed a set of HtVs for the purpose of educating the online SCI community, including newly injured individuals, about the skills and techniques necessary to effectively perform a variety of everyday tasks (Schladen et al, 2011). A series of studies was conducted exploring qualitative and quantitative aspects of SCI-specific education videos generally available on YouTube, as well as those specifically developed by the RRTC team (HtVs). Studies focused on 3 aspects of the SCI-focused educational videos: (A) content analysis of SCI-specific educational videos posted on YouTube, (B) therapists' evaluation of SCI HtVs, and (C) analysis of viewers' responses to SCI HtVs published on YouTube.

Figure 1: Screenshot of "How-To: video "How to Cook in a Wheelchair."

The screenshot shown in **Figure 1** illustrates the way the HtV is presented on YouTube. It shows an SCI-Navigator, a person with the C5-6 (level of severity) SCI, demonstrating how she cooks from a wheelchair.

2.2.2 Phase a. Content Analysis of YouTube Videos Focused on SCI

A search query on YouTube using the YouTube Analytic engine and the key words "'How-To' videos," "SCI," "self-management," and "patient education" returned about 10,900 video entries (as of November 13, 2013). A previous selective analysis of the first 1,000 search results in 2010 suggested that the first 100 entries were representative of the content of SCI-specific videos posted on YouTube between 2006 and 2010. These 100 video titles, content confirmed by reference to the video's abstract, were analyzed with regard to the cross-cutting topics and were further combined in categories.

Data analysis focused on how SCI inquiries were addressed by both the individuals who uploaded videos and their viewers by defining categories that adequately described the spectrum of SCI-related videos. The search-generated data were analyzed to describe the frequency of the identified topics. A list of topics was analyzed through sorting qualitative descriptive data (Chwalisz et al, 1996). Each category was then further divided into several subcategories specific to the single problem domain. Categories of SCI-related on-line education videos emerged as follows based on the frequency of their appearance on the Web (see Figure 2):

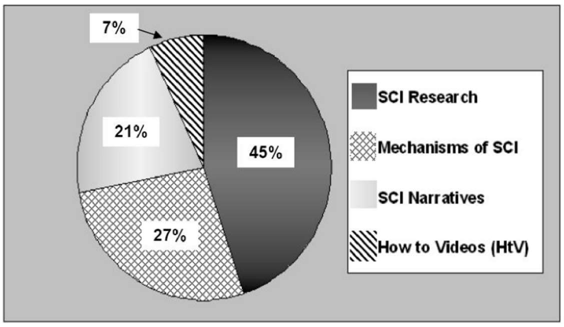

Figure 2: SCI-related multimedia health literacy videos.

A1. SCI research, inclusive of both recovery (including the ongoing debate concerning stem cells, cell-based therapies), and health/wellness research on quality of life, nutrition, and accessibility barriers.
A2.Mechanisms of SCI, including understanding levels of SCI and associated levels of functioning
A3. SCI narraitves, including personal stories of SCI survivors, sharing family experiences of coping with SCI
A4. HTVs, with the most frequent topic being exercise videos (athletic, swimming, adaptive tennis, and skiing) (see Phase C).

SCI research health literacy videos were the most viewed videos in the analyzed sample (45%). Videos on how to understand the link between the severity of injury and everyday functioning were the second (27%) most reported. The third most common category (21%) included videos on personal stories, or narratives describing day-to-day challenges for persons with SCI and sharing experiences of living with disability. The least frequent category included instrumental or HtVs that provided various types of guidance on daily task performance. As was evident from their comments requesting additional videos showing variations in demonstration, YouTube viewers found content more accessible when they were able to view a peer enacting the task they wished to accomplish.

2.2.3 Phase B: Therapists' Evaluation of SCI HtVs

Patient-oriented multimedia products, such as SCI HtVs, are created in the wider context of clinical, research, and training practice. For this purpose, 10 HtVs were developed by an occupational therapist (OT) in collaboration with a senior peer mentor/educator to model adaptive skills that could be most effectively and clearly demonstrated by an individual who actually uses a wheelchair. Videos depicted techniques a person with SCI might use to increase independence in driving (transferring to and from a car), floor transfers (from wheelchair to floor and back to wheelchair), use of public transportation (up and down the escalator and riding the metro), and daily activities such as putting on boots from a wheelchair and cooking from a wheelchair.

Thirty-one physical therapists (PTs) and OTs experienced in working with patients with SCI viewed HtVs on car transfer/driving, floor transfers, and riding an escalator. Therapists evaluated the videos and ranked them on a 3-point Likert scale (where 3 was high and 1 was low) in terms of (a) utility of the skills they demonstrated, (b) helpfulness in fostering self-efficacy, and (c) usefulness in demonstrating skills that otherwise could not be demonstrated. Thus, each participating therapist viewed the videos and ranked them with regard to 1 of the 3 concepts, for example, how a particular video may promote a feeling of self-efficacy or how a specific video could be useful in the everyday routine of a person with SCI.

Data analysis using Kendall's W test demonstrated that the floor transfer video was associated with the concept of fostering self-efficacy (M=2.30, P=0.37) and showed a similar trend with the perception of utility of skills (M = 2.42, P = .057), while the escalator video was associated with adaptation to the environment, though non-significantly (M = 2.23, P = .33). Analysis of open-ended questions demonstrated that clinicians considered the videos to be an important addition to patient self-management education.

2.2.4 Phase C. Community Response to SCI HtVs

Initially the study evaluated viewers' responses to 10 SCI HtVs on YouTube using the YouTube statistic utility, Analytics. Since this initial analysis in 2010, the Healthy Tomorrow YouTube channel developed as part of our project and use as a platform for posting HtV, has grown to include 47 videos. Topics treated in these videos included "How to Do Pressure Reliefs in a Wheelchair and "How to Cook in a Wheelchair," themes highly germane to the ultimate knowledge translation objectives of the RRTC, as well as more eclectic, general interest topics such as "How to Take off Boots" and "How to Transfer from Wheelchair to Bed and Bed Mobility." More recently, the Healthy Tomorrow Channel has introduced HtVs for weight-lifting and other gym activities.

The new data were analysed to show the community response to HtVs during the 30-day period, October 13 through November 11, 2013.

Views ranged from nearly 1,400 to just under 100, demonstrating that all SCI life skills may not all be of uniform interest. The video demonstrating the more basic life skill of transferring from wheelchair to bed and bed mobility was by far the most engaging of any of the HtVs. It captured nearly 400 more views than the next most popular video, one that showed how to transfer from wheelchair to floor.

In fact, since its publication in September 2009, the wheelchair-to-bed transfer and bed mobility video has demonstrated a constant rate of daily access as reported for November 10, 2013, which was 55 views. More investigation is needed, but the relative popularity of a very basic life skill (transferring from wheelchair to bed) versus an unusual and "edgy" life skill (going down the escalator in a wheelchair) suggests that most HtV viewers are persons with SCI, persons with other mobility disabilities, or family and friends. We hypothesize that a person without a disability who accesses HtVs out of curiosity would be more drawn to dramatic and unusual skills demonstrations, such as riding an escalator in a wheelchair. Comments posted and subscription requests further suggest that most of the viewers of HtVs were persons with SCI, family, or friends. Most HtVs focused on SCI life skills were "discovered" on YouTube by referral from related videos. In October and November 2013, seventy-four percent of the persons who engaged the wheelchair-to-bed HtV found it through a related YouTube referral.

This number is significant when we realize that referral from other videos is not the only way persons connect with one another in the YouTube community. We associated key words with this popular video: "wheelchair," "SCI," "bed mobility," "transfer," "peer mentor," "spinal cord injury," "NRH," and "disability awareness." Only a small minority (11.6%) of viewers arrived at the wheelchair-to-bed video by searching one of these key words inside of YouTube. An even smaller number (0.5%) found the HtV from the Google search engine outside of YouTube. Rather it was YouTube's own "interest engine" that connected interested people with our demonstration of wheelchair-to-bed transfer. YouTube utilities "observe" users' patterns of interest and viewing and suggest other community resources. Most viewers, therefore connected with the wheelchair-to-bed HtV without explicitly knowing that they wanted to. Long-term viewing patterns were sinusoidal, suggesting that viewers alerted one another to the videos' existence. Viewing accelerated and then dropped; subsequently, the pattern repeated. HtVs dealing with the RRTC themes of diet and skin management skills (ie, the videos on how to cook from a wheelchair and how to do pressure reliefs in a wheelchair) appear to have about the same number of referrals from related videos as does the most popular wheelchair-to-bed transfer video. In fact, every referral to the RRTC-themed videos, without exception, was made from our popular wheelchair-to-bed HtV. The power of referral in connecting people with SCI with information that they may not initially find engaging is a topic for continued investigation.

Among the data returned by the YouTube web statistics utility, Analytics, was the geographic location of view requests. In the lifetime statistics of the channel, viewers were located largely in the United States (31.4%), but a significant number of views originated in Europe, especially in Germany (11.5%), and in South America and Asia. The appeal of HtVs, narrated in English, to persons who likely are not native speakers suggests the utility of video demonstration of skills.

According to a survey conducted by the Pew Internet & American Life Project, 91% of Americans own a handheld device (cell phone, smart phone), Of individuals who own mobile devices, 40% have used it to access social networking on-line (Duggan, 2013; Brenner, 2013). As use of the mobile Web grows, persons with disabilities are likely to be a percentage of those users. During October and November of 2013, YouTube documented a median value of 16.1% of HtV views as originating from mobile phones, while 11.0% originated from tablets. This is a four-fold percentage increase in mobile device viewing since 2010. One video theme, however, represented by "How to do One Arm Cable Bicep Row/Curl with a Cable Machine" garnered a remarkable 30% of its views from persons believed to be using mobile devices. This unusual rate of mobile access coupled with the mobile theme of the HtV suggests persons who accessed this video from their handhelds may have been looking for real-time support in solving problems they were encountering while exercising at the gym. Alternatively, they may have specifically invoked the HtV from a mobile device to use it as a reference while practicing the skills it demonstrated at the gym.

2.2.5 Discussion: Persons with Disability Interests in Social Media

Each of the 3 phases of study described in this article create a tentative profile of SCI interests as they present across the social media site, YouTube. A dichotomy of cure versus care can be used to describe the results of the content analysis. SCI research educational videos were the most common videos in the analyzed sample (45%). Videos on how to understand the link between the severity of injury and everyday functioning were the second (27%) most reported. The third category (21%) included videos on personal stories, or narratives, describing day-to-day challenges for persons with SCI and sharing experiences of living with disability. Finally, the least frequent category included instrumental videos, or HtVs, that provided various types of guidance on daily task performance. You-Tube viewers found content more accessible when they were able to view a peer enacting the same task they wished to accomplish, as demonstrated by a preponderance of comments asking for additional videos showing variations in demonstration.

Findings from Phase B of the research on clinician's perceptions of how HtVs might benefit persons with SCI by addressing such specific areas of self-management as "developing a sense of self-efficacy" or "mastering the SCI-specific skills" support a patient-centered paradigm of care; with reduced length of stay in inpatient rehabilitation, mobility and function videos can play an important role to increase independence in individuals with SCI.

Further, data from Phase B regarding associations between specific features of HtV and self-management for disability concepts are validated by the analysis of the view volume in Phase 3 of the study. The most stable Web-driven behavioral patterns were those that can be described as a combination of the video content, such as mastery of SCI-specific skills necessary to effectively function in everyday situations, and a high frequency of viewing volume.

3 CONCLUSIONS: PEER-TO-PEER KNOWLEDGE MOBILIZATION AS COMMUNITY INTEGRATION

A peer-to-peer knowledge mobilization approach promotes self-management of health and community integration after an individual has been impacted by a traumatic event. A library or repository of multimedia health literacy on-line HtVs available free of charge through support groups, rehabilitation programs, and on-line forums will provide a variety of models for individuals with an SCI for learning new ways to carry out activities of daily living. The HtV paradigm in multimedia-based education for health care needs to advance a new methodology based on a more individualized, disability-specific approach while employing videos as learning tools.

ACKNOWLEDGEMENTS

This project is funded in part by National Institute on Disability and Rehabilitation Research (NIDRR) grant H133B031114, Rehabilitation Research and Training Center on SCI: Promoting Health and Preventing Complications through Exercise, and by NIDRR grant H133N060028, The National Capital Spinal Cord Injury Model System.

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Coping Intelligence
A Blueprint for Multimedia Patient Education

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Keywords: Life Difficulties, Multidimensional Positive Coping Model, Coping Intelligence, Self-management Skills, Theory for Multimedia Education, Well-being Assessment, Effective Coping, Defensive Behaviours.

Abstract: This paper presents a new approach to the theory of multimedia well-being literacy education based on the concept of Coping Intelligence. Multidimensional Positive Coping Model includes three cross-cutting parameters differentiating each coping strategy as efficient or inefficient, emotional, cognitive or behavioral, and active or passive. Results of the statistical analysis verified a basic two-factor structure of the Coping Intelligence with the alternative solutions for efficient and inefficient coping strategies characterized via three basic modalities. The unified methodology underlying the new concept of Coping Intelligence, as well as *Coping IQ* assessment, is applicable for developing multimedia well-being literacy applications for both clinical and general populations. *CIQ* parameters might serve as useful feedback while assessing changes in individual coping repertoire, for it measures not stable traits, but strategies that can be modified as a result of life experiences or educational training.

1 INTRODUCTION: COPING INTELLIGENCE AS A SCIENCE OF HUMAN STRENGTH

'Creating a science of human strength' is a promising direction of modern psychology focuses on 'systematically building competence, not on correcting weakness' (Seligman, 2000). New course of psychological research and practice is based on a healthy, positive model of human behavior. The basic principles of positive psychology strongly correspond to the guidelines of differential psychology, whose primary goal is to explore the unique abilities and strength of human individuality (Libin, A., 2008). The concept of human competence is an ideal starting point for studying the complexity of human individuality as well as investigating the fundamental issues such as quality of living, satisfaction with major life outcomes, self and others.

2 TRADITIONAL APPROACH TO EFFICIENT AND INEFFICIENT COPING

There is a huge need among academic professionals and practitioners, as well as among people with various chronic health conditions and disability, for knowledge on how to empower individual competence by mastering of efficient coping skills. However, existing studies on coping with life difficulties are very contradictory. Literature analysis of relevant concepts and related measures revealed two major trends: coping with stress (Lazarus and Folkman, 1984; Carver and Scheier, 1994) and applied problem solving (D'Zurilla and Nezu, 1990; Heppner et al., 2004). The most known in the first designated area of research is a cognitive theory of stress, developed by Lazarus and Folkman (1984), that interprets coping as either problem- or emotion-oriented. Problem-focused coping is directed toward managing a stressful situation and takes place 'if cognitive appraisal tells that something can be undertaken'. Emotion-focused coping is directed toward regulation of emotional responses and occurs 'when cognitive appraisal tells that nothing can be done' in order to resolve a stressful situation (Folkman and Lazarus, 1985). This approach frames the development of The Ways of Coping (Lazarus and Folkman, 1984), which is a widely used instrument in health and clinical studies. Although this concept and the instrument proved to be very reliable in studying stress-evoked coping responses, a major limitation of this approach in the context of coping with everyday life difficulties is that emotional strategies are viewed as inefficient, whereas cognitive and behavioral strategies are always considered efficient.

A second trend in coping research emphasizes the importance of studying social aspects of problem solving competence through attitudes and underlying belief systems. An example is the theory by D'Zurilla & Nezu (1990) who developed a Social Problem Solving Inventory (SPSI) consisting of the problem solving skill scale (PSSS) and the problem orientation scale (POS) that includes cognitive, emotional and behavioral subscales. Although the POS views cognitive and behavioral dimensions as separate categories, an emotional problem solving strategy still has the same negative connotation and is measured as an inefficient strategy.

The merge of the traditional applied problem solving concept and the stress-related coping theory resulted in Problem-Focused Style of Coping Scale (PF-SOC) developed by Heppner with colleagues (2004). The perceived effectiveness of a problem solving activity is viewed as the degree to which one's actions facilitate or inhibit progress toward a resolution of the problem. The PF-SOC measures 18 strategies organized into three factors – reflective, reactive and suppressive styles. *Reflective style* measures cognitive activities that promote problem solving, whereas *reactive style* emphasizes distorted cognitive and emotional activities. Denial and avoidance form *suppressive style*. A cognitive strategy is analyzed as efficient or inefficient depending on the organization of the cognitive efforts, whereas emotional strategies along with behavioral ones, are defined as strictly inefficient.

2.1 New Positive Coping Model: Efficient and Inefficient Management of Everyday Life Difficulties

The above described traditional approaches, while identifying cognitive, emotional, and behavioral aspects of coping, often confuse the modality of the strategy with its functionality and outcome. This conceptual drawback presents quite a few challenges to the measurement of efficient and inefficient strategies in coping research and psychological practice.

First of all, our review illustrates that the study of efficient and inefficient strategies has been limited in scope and in the choice of basic parameters. For instance, the inadequate conclusion that cognitive efforts are always efficient while emotional activities are always inefficient is based on a false assumption that basic parameters differentiating between efficient and inefficient strategies are associated with only one predominant modality. *Secondly*, existing models offer a very unclear depiction of the role of behavioral efforts. Behavioral strategies either form a separate category of inefficient coping (D'Zurilla and Nezu, 1990), or are combined with cognitive efficient strategies in one single class (Lazarus and Folkman, 1984; Carver and Scheier, 1994). *Most importantly,* according to the existing traditional approaches emotional strategies are viewed contradictory to cognitive and behavioral ones. In the last two decades, numerous studies proved the beneficial role emotions play in resolving life difficulties. Data suggest that particular characteristics of emotional experience such as optimism, hope, and emotional intelligence positively influence the coping process (Seligman, 1991; Snyder, 1998; Averill, 2000; Fredrickson, 2002). Salovey and Mayer, defining the concept of Emotional Intelligence (1990), stated that 'emotion and intelligence are not mutually contradictory'. Emotional strategies may be inefficient if they are used inadequately and efficient if they employed adequately for the process of resolving life difficulties. Used correctly and adaptively, emotions help in reasoning, information processing and problem solving by prioritizing thinking, shaping memory and facilitating creativity. This findings support a new paradigm of understanding human intelligence that overcomes the limitations of 'pure intelligence' (Gardner, 1999) and its role in individual well-being. The contemporary view on individual competence considers emotional, cognitive, behavioral, and social abilities as integral parts of generalized intelligence (Goody, 1995; 2000; Libin, E., 2004; Sternberg et al., 2003). *In sum,* traditional perception of the incongruency between modalities (cognitive, emotional, or behavioral) of a particular strategy and its functionality or organizational efforts (efficient vs. inefficient) hinders the development of an integrated methodology for a generalized coping process and the design of an adequate assessment instrument.

A proposed concept of Coping Intelligence based on Multidimensional Positive Coping Model (Libin, 2003a) lays at the foundation of a new blueprint for multimedia patient0centered education. This model strives to overcome limitations in studying coping by suggesting cross-cutting parameters for the unified classification of efficient and inefficient strategies. Coping Intelligence is defined by the quality, functionality, repertoire, and efficiency of cognitive, emotional, and behavioural strategies of varying intensity.

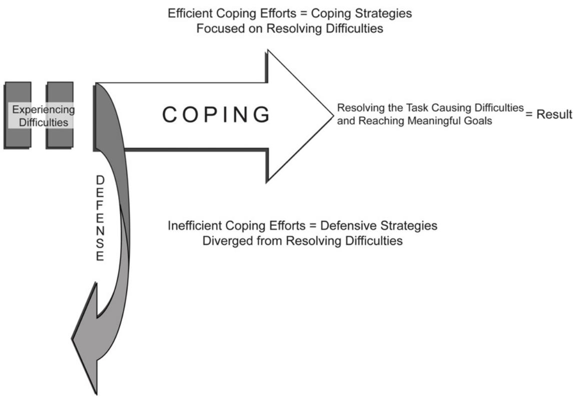

Figure 1: Multi-dimensional Model of Coping Intelligence as a Conceptual Framework for Patient-Centred Multimedia Education.

Taking into account the new findings on generalized properties of human intelligence described in the previous section, the proposed model categorizes efficient and inefficient strategies based not on their modality, but on *their functionality or the organization of coping efforts*. According to the Multidimensional Positive Coping Model each strategy is characterized by:

- ***The primary cross-cutting parameter**: organization of the efforts* (efficient or inefficient)
- ***The secondary cross-cutting parameter**: modality of manifestation* (emotional, cognitive or behavioral), and
- ***The tertiary cross-cutting parameter**: intensity of efforts* (active or passive)

Thus, *the organizational efforts* define a coping activity as efficient or inefficient, whereas *the modality* characterizes any given efficient or inefficient strategy as emotional, cognitive or behavioral. In addition, each emotional, cognitive or behavioral strategy can be evaluated as active or passive depending on the intensity of provided efforts. Hereby, a strategy is defined as a vector of emotional, cognitive, or behavioral efforts of varying intensity resulting either in an effective or ineffective outcome for dealing with life difficulties.

Efficient coping strategies *focus on* the resolution of the difficult situation. Accordingly, inefficient coping strategies *diverge from* the resolution of life difficulties.

2.2 Coping Intelligence™ Model*:* Experimental Analysis

Based on a newly developed model, a *Coping Intelligence Questionnaire (CIQ; Libin, 2002, 2003, 2008)* differentiates between efficient or inefficient strategies as they relates to three modalities – *cognitive*, *emotional*, and *behavioral*, while including three measures of the primary orientation such as *self-, subject- or others-oriented,* and two measures of the intensity of individual involvement with difficult situation, such as *passive or active (see Figure 2)*. A central element of the Coping Intelligence™ framework is a conceptual classification scheme that allows describing each efficient or inefficient strategy according to four criteria: organization of the efforts that a person exhibits in a difficult situation; leading modality of the efforts; an orientation vector of employed efforts; and intensity of the efforts.

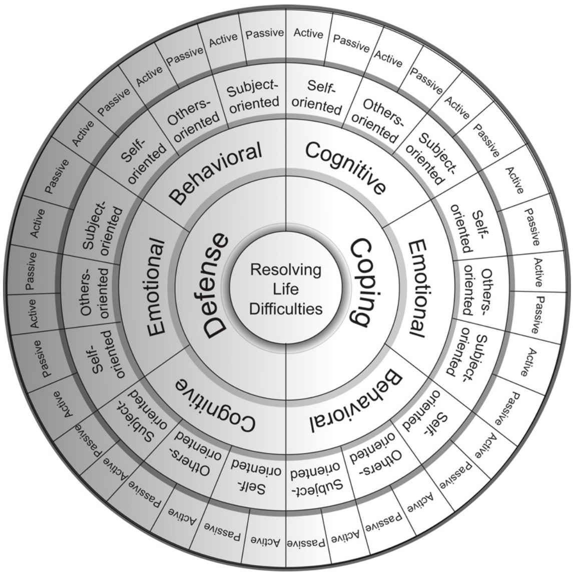

Figure 2: Experimental Coping Intelligence™ Framework.

The present article focuses on the first experimental phase of the new assessment tool development, whereas a theoretical framework for the positive coping approach is described in details elsewhere (Libin, 2003 a,b).

2.2.1 Research Methodology

Four consequential steps were performed in developing the *Coping IQ (CIQ)* assessment including (1) literature analysis and the development of a pool of items, (2) studying content validity of the new measure through the expert review panel, (3) exploring psychometric properties of the *CIQ* via Cronbach alphas, (4) and validation of the proposed measure via the analysis of individual differences in efficient and inefficient coping strategies with relation to age, gender, temperament, and subjective evaluation of meaningful life outcomes.

The sample consisted of 114 participants with the mean age of 25.7 years including 28 (25%) males and 86 (75%) females. Participants were adolescents, recruited from public high school and college, and adults attending secondary education classes. The presented data is part of a larger cross-cultural study on coping with life difficulties currently being conducted in the U.S. Russia, and Ukraine.

Participants who were enrolled in academic programs were approached for informed consent through the Office of Academic Programs. All participants were assigned a number for the study, thereby maintaining their anonymity. Researchers involved with the project were trained and sensitized to the importance of confidentiality of the data.

The *Coping IQ* instrument *(CIQ)* is designed to measure cognitive, emotional, and behavioral responses to a difficult situation viewed as a meta-concept of problematic events that trigger coping efforts. *CIQ* is a self-report measure consisting of 72 items, which assesses 3 efficient and 3 inefficient scales differentiated by the cognitive, emotional, and behavioral modality of coping responses. The instruction asks a participant to indicate whether he or she employs a particular strategy while facing a difficult situation, using a 5-point Likert-type scale of frequency with '1= never' and '5=always'. Outcome variables included 3 measures of efficient and 3 measures of inefficient coping scales, two general indexes for efficient and inefficient strategies and four indexes for active and passive efficient and inefficient measures, as well as a combined quantitative measure named *coping intelligence quotation* calculated as a ratio of efficient strategies index divided by the inefficient strategies index. All indexes and scales were calculated as a mean of appropriate strategies. Each of six *CIQ* basic scales can be briefly described as follows:

- Efficient cognitive coping is characterized by cognitive activity ***focused on*** the resolution of the difficult situation, whereas inefficient coping characterizes cognitive activity ***deviating from*** the task at hand.
- Efficient emotional coping is comprised of emotional efforts ***concentrated on*** the problem's solution, while inefficient coping is associated with the emotional efforts ***divergent from*** resolving difficulties.
- Efficient behavioral coping consists of behavioral efforts ***applied toward*** resolving the difficulties. At the same time, inefficient coping characterizes behavioral activity ***deviating from*** problem-solving.

Subjective Life Satisfaction Scale (SLS) was developed and validated by the author in previous studies (Libin, 2003b). *SLS* measures subjective satisfaction with life goals, self and relationships with others on the 12 item Likert-type self-evaluation scale from '1=completely dissatisfied' to '5=completely satisfied'. Items refer to 5 separate, but interrelated aspects of one's life – indexes of satisfaction with meaningful life outcomes ('things that happened in my life', 'projected goals', and 'the way the life goes'), and indexes of satisfaction with socially-oriented life areas including distant relationships (with superiors, colleagues, and peers) and close relationships (with friends, parents, and other family members). *SLS* also includes three single items evaluating satisfaction with self, professional relationships, and relations with the opposite sex in general. *SLS* was tested on 60 people of both genders with the age mean of 27.4 years. Psychometric analysis showed a sufficient level of internal validity of scales with the range of Cronbach alphas from 0.84 to 0.93.

The Object-related and Communicative Temperament Inventory (*STQ;* Rusalov, 1989) is based on the four-phase algorithm underlying Anokhin's functional systems model (Anokhin, 1975). The *STQ* comprises 105 "agree-disagree" items organized in eight scales, measuring 4 basic temperamental parameters including ergonicity, plasticity, tempo and emotionality as they relate to social-oriented (communicative) and object-oriented areas of human activities. Four object-oriented scales measure ergonicity (Er), plasticity (P), tempo (T) and emotionality (Em) reflecting different aspects of mastering the object world. Social-oriented scales such as ergonicity (SEr), plasticity (SP), tempo (ST), and emotionality (SEm) measure respectively the level of social activity, the ease of switching from one social contact to another, the speed of social performance, and sensitivity in the communicative sphere. The *STQ* is shown to be a valid and reliable measure of temperament with Cronbach alphas ranging from 0.72 to 0.84 (Rusalov, 1989; Bishop and Hertenstein, 2004).

During the study, 128 participants were administered a set of three questionnaires over a one-month period. A qualified researcher supervised the assessment performance. Each participant conducted self-evaluation individually. 14 participants were unable to compete the whole set due to the different reasons, therefore a total of 114 participants were included in the final analysis. Data were analyzed using SPSS 12.0.

2.2.2 Experimental Findings: Relationships between Effective and Ineffective Coping and Individual Characteristics

The study of content validity of the *CIQ* was conducted through the expert review panel, which included four experts familiar with the literature on coping. All experts were psychologists and academic professionals experienced at teaching high school, undergraduate and adult students. The panel reviewed all *CIQ* items prior to the testing. Necessary word changes were made so that the proposed items would be better understood by the participants. Then experts reviewed the list of items, rating relevance of the items to efficient or inefficient coping. The initial pool for the questionnaire included 180 items, which after initial reviewing with the group of four researchers was narrowed down to 108 items. During the next step an internal consistency of the *CIQ* was studied via data collected from 114 participants. As a result 36 more items were excluded, leaving 72 items with most significant loading organized in six scales with Cronbach alphas ranging from 0.72 to 0.81.

The next step was to study a structure of the *CIQ* via factor analysis. We assumed that two basic dimensions, inefficient and efficient coping, would be associated with two different factors. This structure of the *CIQ* was confirmed by the principal component factor analysis with Varimax rotation of 72 items. The result revealed a basic two-factor structure with the alternative factor solutions for efficient and inefficient strategies. Each efficient or inefficient factor included strategies of all three (cognitive, emotional and behavioral) modalities. The relationship between efficient and inefficient coping, measured by *CIQ,* and gender, age, and individual characteristics such as temperament and life satisfaction were studied on groups of 61 and 70 people respectively. Additionally, gender differences were studied on the balanced by age group of 48 people including 24 male and 24 female.

2.2.3 Gender and Age Differences in Efficient and Inefficient Coping

Analysis via independent sample using Levene`s test for equity of variances as a statistical measure (F) of the differences between the groups (N=48) showed no significant gender-related differences regarding the preference of efficient vs. inefficient strategies. Comparison by Levene`s test between two balanced by gender age groups – 15 – 16 year old (N=31) and 17 – 21 year old (N=36) – revealed significant differences in inefficient emotional and efficient cognitive coping scales. Additionally, comparisons revealed differences in the integrative coping intelligence quotation, as well as in the intensity of coping efforts measured through indexes of active and passive strategies. Only outcomes with an alpha level of less than .05 were considered for interpretation. Distribution of the analysed variables was fairly symmetric and had no outliers.

Correlation analysis of the coping, subjective life satisfaction and temperamental parameters, measured respectively via *CIQ*, *STQ* and *SLS,* confirmed our initial hypothesis about the links between inefficient strategies, life dissatisfaction, and temperamental impulsivity and neuroticism. Results of the correlation analysis showed that a higher index of *inefficient coping* via *CIQ* was associated with the lower levels of meaningful life outcomes, including goals, major life events and future prospects, personal well-being, and social relationships. The largest number of significant correlations between *ineffective coping* and low scores on *STQ* was found for the parameters of temperamental emotionality (neuroticism) and tempo (impulsivity). Cognitive, emotional and behavioral ineffective coping strategies were also associated with subjective dissatisfaction in various domains of life. The general index of inefficient coping, measured as a mean of all three scales, correlated negatively with major life satisfaction parameters. Statistically significant links were found between coping strategies and all temperamental parameters, with the exception of object-oriented ergonicity and plasticity. In sum, *inefficient coping* correlated positively with neuroticism and negatively with social impulsivity and activity. *Efficient coping* was positively associated with both socio-oriented plasticity and temperamental activity, while negatively with neuroticism products, such as A T-test was performed to clarify the structure of the relationships between different levels of coping intelligence quotation, temperament and life satisfaction. The comparative analysis of groups (mean age 23 years) with high and low levels of *coping intelligence quotation* by temperament and subjective life satisfaction revealed that individuals with *efficient coping* are characterized by a higher level of *social-oriented plasticity* ($t_{(39)}= -3.05$, $p<0.04$) and *index of social-oriented activity* ($t_{(39)}=-3.36$, $p<0.02$). Individuals with *inefficient coping* are distinguished by the higher level of *object-oriented tempo* ($t_{(39)}= 2.14$, $p<0.04$).

Also, participants with high levels of *inefficient coping* are characterized by an increased level of dissatisfaction with *meaningful life outcomes* ($t_{(34)}=-2.47$, $p<0.02$), *social relationships* in general ($t_{(34)}=-2.56$, $p<0.02$), and *distant social relationships* in particular ($t_{(34)}=-2.53$, $p<0.02$). Individuals with low coping IQ are more dissatisfied with major aspects of life, including 'things that happened in life' ($t_{(34)}=-1.08$, $p<0.05$), 'projected goals' ($t_{(34)}=-2.22$, $p<0.03$), and 'the way life goes' ($t_{(34)}=-1.99$, $p<0.05$). In socially-oriented areas they are especially unhappy with their distant relationships, including those with superiors ($t_{(34)}=-2.62$, $p<0.01$), colleagues and peers ($t_{(34)}=-2.00$, $p<0.02$), with their parents ($t_{(34)}=-2.48$, $p<0.05$), and with their relationships with the opposite gender ($t_{(34)}=-2.06$, $p<0.05$).

The general conclusion is that a *low coping intelligence quotation*, associated with a predominance in individual repertoire of ineffective strategies, is linked with high scores on such individual variables as temperamental impulsivity (tempo) and subjective dissatisfaction with personal achievements and relationships with others. On the contrary, a *high coping IQ*, associated with a predominance of effective strategies, is linked to socio-oriented temperamental flexibility (plasticity) and subjective satisfaction with both personal achievements and social aspects of life.

2.2.4 Discussion: Coping Intelligence in the Context of Learner's Characteristics

The absence of general principles for classification of efficient and inefficient coping poses methodological and practical difficulties in their diagnostics and differentiation, thereby causing additional obstacles in the systematic study of this important phenomenon. The newly developed concept of Coping Intelligence suggests the use of cross-cutting parameters to facilitate the unified classification of efficient and inefficient coping strategies. Results of the factor analysis verified a basic two-factor structure of Coping Intelligence with alternative solutions for efficient and inefficient strategies characterized via three basic modalities.

A theorized relationship between efficient and inefficient coping, positioned in the continuum formed by three basic modalities – cognitive, emotional, and behavioral, guided the development of the *Coping IQ (CIQ)* instrument designed to measure a variety of strategies in all three domains. While *organization of the efforts,* being the primary cross-cutting parameter, differentiates between effective and ineffective coping, the secondary parameter describes each efficient and inefficient strategy as cognitive, emotional or behavioral according to *the manifest modality* of the efforts, whereas the tertiary parameter characterizes each strategy as passive or active.

The final version of the *CIQ* instrument consists of 72 items to ensure high reliability for each of 3 effective and 3 ineffective scales. Outcome variables included six *CIQ* basic scales, two general indexes for efficient and inefficient strategies, and coping intelligence quotation calculated as a ratio of efficient coping index divided by the inefficient coping index. As a quantity indicator, coping IQ shows whether efficient or inefficient coping strategies prevail in the individual's repertoire.

Results showed that adults employ efficient strategies more often than teenagers. Changes in coping related to age dynamics suggest that individual efficient coping repertoire arises initially as a result of the development of emotional and cognitive mental processes. Our findings also confirmed that not only emotional, but also cognitive and behavioral inefficient strategies are associated with low life satisfaction.

The greater number of statistically significant correlations between temperamental characteristics and inefficient strategies demonstrates close ties between formal-dynamic, biologically determined, variables and inadequate ways of dealing with difficult situations. In comparison to efficient coping, inefficient strategies also revealed a much greater extent of negative association with subjective life satisfaction parameters, thus illustrating strong association between inefficient coping and personal dissatisfaction with various aspects of life. In sum, *efficient* and *inefficient coping strategies* demonstrate reverse relations with both temperamental (formal-dynamic) and subjective life satisfaction (socio-psychological) characteristics.

3 CONCLUSIONS

The association between inefficient coping strategies and *object-oriented temperamental impulsivity (high tempo)* corresponds with the data on increased problematic behaviors in persons with high levels of impulsivity (Horton and Oakland, 1997; Mcevoy and Welker, 2000). This allows us to make an assumption that abundant psychomotor activity is negatively associated with coping outcomes. Our findings also suggest, that it is not the speed of object-oriented mental operations and motor acts performance, but rather the accuracy with which mental and motor activity are performed (*adequate and timely channeled tempo)* along with the plasticity of social-oriented activity, contribute to the successful resolution of difficult situations. In the realm of social relationships, a broader repertoire of communicative programs, and flexibility in social relationships and in establishing social contacts (indicators of high *social plasticity)* are most likely to result in more efficient ways of handling life challenges. These individual trends should be considered in tailoring multimedia education to the need of the end users as part of the overall program on well-being literacy.

ACKNOWLEDGEMENTS

This article was supported in part by the Coping Institute (USA), the Department of Psychology at the Georgetown University (USA), and the Laboratory of Differential Psychology and Psychophysiology at the Institute of Psychology, Russian Academy of Education. The author would like to express sincere gratitude to Dr. Alexander Libin, Dr. James T. Lamiell, Dr. Nickolay Aminov, and Dr. Michael Kabardov for their contributions to the article and continuing support of the coping intelligence project. The author is thankful to Ms. Erica Molly Lessem and Ms. Jennifer Bresnahan for their dedication to this study.

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SHORT PAPER

The Use of ICT for Teaching in a Poor Resource Setting

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Keywords: Microwave, Windows, Mac, OS, MEPI, De-centralised.

Abstract: South Africa, like many countries in Africa is plagued by issues related to lack of bandwidth and in many of our rural districts there is no infrastructure for any kind of internet connection. One of the key objectives of the MEPI programme (Medical Education Partnership Initiative) is to be able to conduct de-centralised teaching to medical students in rural hospitals via video conferencing. These students are normally doing their community service and have no contact with their lecturers.The role of Computer Education and Information technology is key to the successful implementation of the UKZN MEPI ENTRÉE programme. The IT provisioning involves the setup of infrastructure and the rollout of an effective video conferencing system that would facilitate decentralised teaching and learning. IT. The IT brief also entails the planning and rollout of an E-Learning platform to further enhance the effectiveness of the programme. Given the demographic diversity and lack of adequate IT infrastructure to support such and elaborate objective, IT will have to find innovative ways to overcome these challenges.

1 INTRODUCTION

The ENTREE program plans to use various innovative strategies to achieve its aims of student and faculty capacity development and staff retention. These include the use of an established, validated, University and Department of Education approved, postgraduate curriculum in HIV management. This programme will be adapted for delivery to medical, nursing and pharmacy students. The plan is to attract a select group of medical students to concurrently enrol in a parallel research-driven programme as a novel approach to developing a cadre of academic and research staff who are likely to be retained in and contribute significantly to this field. The University of KwaZulu-Natal is one of the leading centres for HIV/AIDS and TB research on the continent and has been associated with many recent breakthroughs in both the basic science and clinical management aspect in the field. It is ideally poised in achieving the aims of the programme having already graduated co-registered medical students in basic science higher degrees. In addition, changes to the medicine curriculum have seen the acceptance of many students with a research background into the undergraduate medical programme which include both Honours and Masters students. While such students are a minority, they potentially serve as an existing cohort in implementing the goals of this programme.

2 INFORMATION AND COMMUNICATION TECHNOLOGY (ICT), A TEACHING TOOL

Information and communication technology (ICT) is now recognised as a rapidly emerging powerful educational medium with innovative methods to allow global dissemination of information. (1) (Taylor et al., 2008). As ICT use expands particularly in the developing world, an increasing percentage of the world's population is gaining access to knowledge resources (2) (Taylor et al., 2008, Beux and Fieschi, 2007). The number of cell-phone users in China already exceeds people in the US. Even Africa is experiencing rapid technological advancements, now considered the world's fastest growing mobile telephone market, with a growth rate of 62.4% per annum (Taylor et al., 2008). The impact of HIV/AIDS on healthcare workers has been significant, with increased case burden, treatment of complex patients and long working hours. Further, poor pay, poor working conditions, isolation and lack of educational opportunity serve as contributing factors to the low appeal of healthcare work as a career (3)(WHO, 2006). For those already in the healthcare sector, out-migration accelerates in the presence of these conditions. The 2006 World Health Report revealed that non-physician providers such as nurses and midwives accounted for between 50-90% of all global healthcare provision. In light of the global nursing shortage, it is unsurprising that these health workers are easily lured away from developing nations; a trend likely to accelerate. So the question arises if ICT could be used as an adjunct to scale-up human resources in healthcare and (more importantly) to slow the outflow from developing nations. The potential avenues for success in this sector are multiple. The African Medical Research and Education Foundation (AMREF) has developed and implemented a program in Kenya with distance education as a key component to "train-up" 22,000 nurses within 5 years (4) (Taylor et al., 2008). Geneva University Hospitals have linked with a network for eHealth in Africa, to create a low cost distance educational network incorporating even the most remote central African rural areas of (Geissbuhler et al., 2007). The RAFT (Réseau en Afrique Francophone pour la Télémédecine) program is an example of global connectivity for Distributed e-learning. Despite infrastructure challenges and international bandwidth slower than DSL connections, RAFT, which initially started in Mali, now extends to 10 French-speaking African countries. RAFT successfully enables webcasting of video conferences even at 25 kbits/s; tele-consultations and the ability of physicians and health providers to practice outside of the usually earmarked educational centres. RAFT is an innovative program having successfully overcome barriers which usually inhibit delivery of educational materials through electronic methods in low income resource constraint settings(5) (Geissbuhler et al., 2007, Taylor et al., 2008, Bagayoko et al., 2006).

Telemedicine is the delivery of healthcare services at a distance using communication and information technologies. It involves secure transmission of medical data and information, in multiple formats including image and video for patient diagnosis and management (6,7) (Elder and Clarke, 2007, Saliba et al., 2012). Technological advances have allowed cross-border international delivery of health care(8) (Helble, 2011). For example, the ability to transmit high definition digital images across the world has enabled British hospitals to have access to specialist radiology services from Australian radiologists at night (Helble, 2011, Saliba et al., 2012). Despite this, the global telemedicine market is expected to grow from US$9.8 billion in 2010 to US$23 billion in 2015 (7)(Saliba et al., 2012).

2.1 Learning Management Systems

The so-called learning management systems (LMSs), offers a super ordinate structure to dedicated content. It provides organised and structured content to students (or interns), generally in a modular fashion and used for many different domains. Often LMSs also provide monitoring tools of material usage, online evaluation and testing, and a forum for communication between learners and teachers. Learning material is posted in a LMS and personalised classrooms can be generated by each user. LMSs of universities are focal points for providing learning material or computer-based examinations to learners(9) (Mildenberger et al., 2011). LMSs range from systems for managing educational records and training, to software for online or university course distribution using the Internet with inclusive features for online collaboration. Tertiary institutions use LMSs to both deliver and augment on-campus courses. Learning content management systems are a related technology focused on the development, management and publishing of the content to be delivered via an LMS

2.2 Moodle

Moodle is an open Course Management System and is commonly referred to as a Learning Management System. It has become very popular amongst lecturers and students alike. **Moodle** (abbreviation for Modular Object-Oriented Dynamic Learning Environment) is a free open-source e-learning software platform, also known as a Learning Course Management System or Virtual Learning Environment (VLE). Originally developed to help educators create online courses focusing on interaction and collaborative content construction, today it is a platform in continual evolution. The first version of Moodle was released in August 2002. As a license-free platform there is no limit to its growth. Institutions can add as many Moodle servers as required. While the main focus of the Moodle project is to provide educators with the necessary tools to manage and promote e-learning, various methods to use the platform exist. Moodle is scalable from a few students in a single classroom to an audience of thousands. Moodle is also used in blended learning to augment face-to-face courses. Its interactive platform has chat facilities, databases, wikis and editable glossaries(10,11) (Wikipedia, Accessed 10 November 2012, Moodle, Accessed 10 November 2012).

2.3 Objectives of the Research

2.3.1 Primary Objectives

- To demonstrate that an appropriate infrastructure and method of working improves the outcome of Medical Students' studies at the University of KwaZulu-Natal and the MEPI Project
- Develop and maintain the LMS and Moodle programs to deliver the MEPI / ENTREE content, ensuring controlled access and secure content transmission.
- Integrate MEPI / ENTREE e-learning software with UKZN IT system and with local departments / partners.
- Ensure suitable software integration between UKZN and Columbia University.
- Develop suitable internet capacity at all clinical sites.

2.3.2 Secondary Objectives

- To enable MEPI / ENTREE to meet the needs of learners in the programme
- To support MEPI / ENTREE in the strategic planning, and process development that is necessary to underpin their developm
- ent and embedding of e-learning.
- To promote learning research, innovation and development that begin with a focus on student learning rather than on developments in technology per se, enabling students to learn through and be supported by technology.

2.4 Results

The results of the MEPI programme and its innovation for video conferencing have exceeded its expected outcomes. This is evident in the fact that primary objective listed above was to provide de-centralised teaching but it has provided the university with a resource that has benefited other departments. Through this innovation patients are being diagnosed remotely and this happens at least once per week through video conferencing to multiple sites.

We have learnt that if we think out of the box it is possible to innovate and conduct teaching even in the poorest of areas. These innovations can sometimes yield results that can benefit a wider population such as the example above.

This was achieved by:

- Use of microwave technology to replace conventional methods of connecting.
- Multi point conference unit which can connect to multiple platforms example Windows, Mac/Ipad OS, and android devices .
- Recording lectures for those who miss them.
  - The use of mobile technology such as cell phones and tablet PC's to view teaching were also unexpected outcomes that the project delivered.

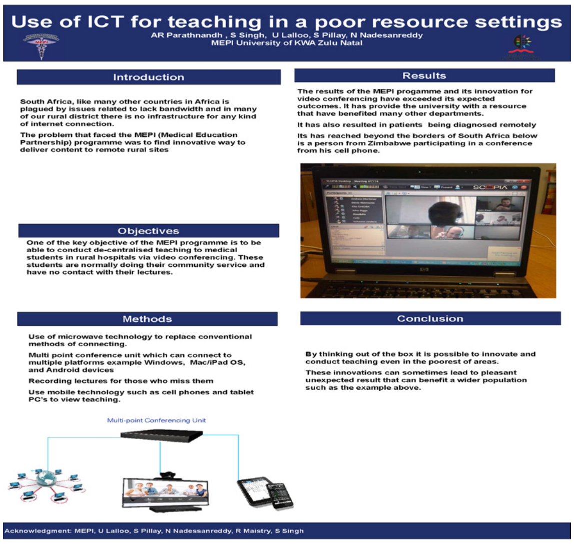

Figure 1.

3 CONCLUSIONS

We have learnt that if we think creatively it is possible to innovate and conduct de-centralised teaching even in the poorest of areas. These innovations can sometimes yield results that can benefit a wider population such as the examples above.

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Proceedings of CSEDU 2014 - Volume 1
6th International Conference on Computer Supported Education
ISBN: 978-989-758-020-8 | www.csedu.org

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