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The impact of digital games in education

by Begoña Gros

Abstract

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In recent years, electronic games, home computers, and the Internet have assumed an important place in the lives and children and adolescents. New media are causing major changes in the nature of learning. There is a vast gap between the way people learn and the way in which new generations approach information and knowledge. Nonetheless, in the formal educational setting the new media are still under-represented.

This paper is based on the idea that virtual learning is central in current society, and that the key aspect of this kind of learning is not so much technology itself but the interaction of the learner with the technology. Virtual learning environments offer many advantages: Flexibility, distribution, and adaptability. However, there is another domain with tremendous potential for reaching, motivating, and fully involving learners: The world of games. We believe that games constitute the most interactive multimedia resource in our culture today.

Children gain access to the world of digital culture via digital games. Our main hypothesis is that children acquire digital literacy informally, through play, and that neither schools nor other

educational institutions take sufficient account of this important aspect. We consider that multimedia design for training and education should combine the most powerful features of interactive multimedia design with the most effective principles of technologically-mediated learning.

The paper concludes with recommendations for future study in order to better understand the growing impact of computers on our youth.

Contents

The digital generation

According to McLuhan (1994), Gutenberg's printing press created the illiterate public. Printing was a watershed in the history of technology: It drew the line between the medieval and the modern. As nobody is born with the ability to read and write, the printing press paved the way for these two skills to become pillars of the educational system. Today, we are in a situation similar to the one that faced industrial society: How to acquire the knowledge

necessary to coexist in the new social, political and economic system. What is special about the challenge confronting us today is that the Internet era presents us with "an everchanging environment to which we must adapt at an unprecedented speed; we must accept that education should equip the individual with the cognitive instruments necessary to cope with this environment" (Fernandez Hermana, 2001).

The existence of this ever-changing environment means that education professionals must respond rapidly by designing new educational areas and contexts. But this rapid response is not always forthcoming. Indeed, the general impression is that many inside the school institution are reluctant to introduce new media into their teaching. Proof of this is the resistance of teaching staff to use software that is not directly adapted to their everyday practices, on the grounds that it introduces subjects that are not in teaching programs or requires them to adopt different approaches to their work.

The use of video games is a good example of this situation. Video games are among the most direct means of access that children and young people have to the world of technology. Most children in the West play with consoles and their first contact with computers is through a computer game. Throughout this article we will suggest that while playing children are learning basic strategies and skills that will enable them to gain access to the virtual world. Furthermore, video games are programs that can easily be introduced in schools to teach specific curricular contents or to develop strategies and procedures.

Video games are among the most direct means of access that children and young people have to the world of technology.

When teachers want to introduce computers in their classes they usually study the types of educational software available in their discipline (Group F9, 2000). This article will not focus on educational software, but on ways of educating by using software. In other words, we will concentrate on the educational processes we aim to implement, and on how to adapt quality products to the educational context. We believe that video games are a good example.

It is still too early to identify the cognitive modifications that the change from a culture based on writing to one based on multimedia will involve. However, a reasonable prediction seems to be that certain features of ICTs will be important elements of change and can guide us in the design of learning materials.

The computer environment not only influences the people who use it, but also has a bearing on the whole of the social context. Several of its effects can already be seen in society at large. Although we do not know their scope and their repercussions in the long run, we believe that we should try to take them into consideration in the design of teaching-learning situations. We can highlight ten aspects that seem particularly interesting: (Prensky, 2001, Tapscott, 1998):

1. Speed

   The digital generation has far more experience in processing information rapidly than its predecessors. The amount of information received and the number of channels available

for exchanging information are greater today than they have ever been. Information is processed at high speed, and — understandably — there is some doubt as to whether this high-speed processing is an aid or an obstacle to knowledge construction. Salomon (2000) defines the "butterfly" effect, and it seems to be a particularly apt metaphor: The choice of a link responds to a split-second impulse that does not often involve much reflection. Nonetheless, this is the aspect that to large extent depends on the educational measures implemented at school and at home.

2. Parallel processing versus linear processing

Many parents are surprised that their children are able to do their homework watching television or listening to a walkman at the same time. The digital generation has an ever increasing capacity for parallel processing which involves a more diversified form of concentration — probably less intense, and less centred on a single aspect. For some authors, this is the result of a process of adaptation to an environment in which we are likely to be carrying out several tasks at once — driving and talking on a cell phone, writing a letter, speaking on the phone and checking our e-mail messages.

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A good example of this design in parallel can be seen on the news channel Bloomberg. As the newscaster reads out the news items, on the screen behind are other images that are totally unrelated to what the newscaster is saying; and at the same time other information to do with the economy or current affairs appears at the top or bottom of the screen. Adults are likely to find this much more difficult to follow than the young.

3. The text illustrates the image

For many years, images and graphics were used to accompany and illustrate text. Today, in technological media it is often the text that is complementary: It is used to expand on something that has already been presented in image form. Greenfield (1996) speaks of the importance of "visual intelligence" and its intense development since the advent of television, cinema and, of course, multimedia.

The challenge for educators is to design ways to use this shift to enhance comprehension, while still maintaining the same richness of information in the new visual context. According to Prensky (2001), "computers and video games designers are specialist in this area, which is a great advantage of digital game-based learning" [1].

4. The end of linear access to information

The digital generation is the first that has experienced a non-linear means of learning. They are comfortable using hypertexts and accessing different parts of the screen in educational games and multimedia, and they regularly surf the Internet. These activities have introduced children and

adolescents to a form of organizing information that is totally different from that used in writing.

5. Connectivity

   The digital generation is growing in a world connected synchronically and asynchronically. Both types of connection offer access to information and to social relations in highly varied ways. For this reason, the new generation tends to approach problems from a different angle; their searches for information and communication are carried out via ICTs.

6. Active versus passive

   There is a big different between reading and interacting with computers. Reading need concentration, silence, working alone. The use of computers introduce more active experiences such as chat, posting, surfing for information. Children and adolescents expect immediate results and become more active. According to Prensky (2001), "we now see much less tolerance n the workplace among the games generations for passive situations such as lectures, corporate classrooms, and even traditional meetings" [2].

7. Orientation towards problem solving

   The increasing emphasis on problem-based teaching is no surprise. The digital generation has an approach to things that is similar in many ways to a computer game: performance and constant revision of the action, without any planning of the processes. "Trial and error" is used a great deal, and possibly the task of the educator is to

counterbalance this type of action in order to encourage thinking, and strategies for planning and problem-solving.

8. Immediate reward

   For Prensky, "the challenge for teachers is to understand the great importance of immediate reward for the young, and to find ways of offering significant rewards instead of advising things that will be rewarded in the long term" [3].

   This is a very important point, since on occasion we may find the responses of students rather confusing. It is often said that pupils ask about the utility of what they are learning. Adults assume that they are asking about its utility in the long term. But what the student wants to know is its immediate applicability — not necessarily in a utilitarian sense, but because she needs an immediate contextualization of what has been learnt. They need to work with "authentic" tasks.

9. The importance of fantasy

   Tapscott (1998), a review of many of the most successful computer games and of the films and novels read by adolescents today, states that fantasy is a key element for today's adolescents. This phenomenon probably has been encouraged by technology but it is not clear if this affect in the same way to both genders.

10. A positive view of technology

    The new generations grow up using ICTs and are highly familiar with them. Unlike adults, their attitude to them is positive.

The differences among between children and adolescents can be seen in the types of technology they use. In this regard, studies of gender are particularly relevant. Though research results have not been entirely consistent in recent years, certain major differences appear to persist between the genders. In the domain of video games, there is a greater preference for adventures and simulation among girls and little interest in action and sports games, which are the ones that most motivate the boys.

Research on video games

Play is a human characteristic, the existence of games appears in the most wide-ranging of cultures. Until the end of the nineteenth century, games had been associated with entertainment, but with the influence of John Dewey (1944), games began to play a major role in the teaching methodology. Games were introduced in the school as something more than just entertainment. The educators were intuitively aware of something that has been corroborated since then by numerous studies: that games have a major educational potential. Not only do they motivate, but they can help students develop skills, abilities, and strategies. This makes them an important part of teaching material in schools.

Most educators consider that it is possible to learn through play. Games form a part of the educational strategies used by teachers at most levels of the school and university system. In fact, it is not

only children that play: Games are devised for language learning, for adult education, and even in organizations (see Prensky, 2001).

Games form a part of the educational strategies used by teachers at most levels of the school and university system.

Play does not take the same shape in informal contexts as in formal ones. Games are transformed when they are used for educational purposes: They are still games but they are used for a specific aim, to learn particular things, and to develop certain strategies and/or abilities. The game is integrated in a context that establishes its own rules as to how it should be used in order to derive maximum educational benefit. In this respect, as Bishop says, "there are more forms of playing than there are games" [4].

In educational and social science discourse, the reactions to new technologies, including digital gaming technologies, have been equally excessive. Some advocates of digital game-based learning imply that developing educational games is a moral imperative, as kids of the "video game generation" do not respond to traditional instruction (Prensky, 2001). Other educators, such as Eugene Provenzo (1991; 1992) worry that games are inculcating children with hyper competitive. According to Squire (2002) "looking at the range of values and powers that educators ascribe to games, games begin to look a bit like a Rorschach test of educators' attitudes toward modern social, technological, and media change, rather than an emerging and maturing entertainment medium".

In our opinion, understanding learning as participation in social practice suggests ways for educators to transform game playing

into participation in social practice. We consider than teachers' adoption and adaptation of materials suggests teachers will adapt the learning materials we create to maximize their potential to support learning regardless of designers' intentions. As such, the pedagogical value of a medium like gaming cannot be realized without understanding how it is being enacted through classroom use.

Activity Theory offers a theoretical framework with strong intuitive appeal for researchers examining educational games. Growing out of Vgotsky's discussion of the mediating role of artifacts in cognition (1978), Activity Theory provides a theoretical language for looking at how an educational game or resource mediates players' understandings of other phenomena while acknowledging the social and cultural contexts in which game play is situated. Learning is conceptualized not as a function of the game itself — or even a simple coupling of the player and game; rather, learning is seen as transformations that occur through the dynamic relations between subjects, artifacts, and mediating social structures.

Many of the existing theories have explained games on the basis of their function, that is, on what underlies the immediate experience of the game, both individually and socially. Calvo (1997) maintains that games can enhance the following functions:

1. *Motor development.* Games often involve movement; they stimulate precision, coordination of movements, and speed.
2. *Intellectual development.* As well as movement, games may also involve understanding how things work, resolving problems, devising strategies, etc.
3. *Affective development.* The fictional nature of games, the opportunity to act out a role means that they have a key function in the affective development of the individual. Games stimulate students to understand their life experiences and help them to mature.

4. *Social development.* Games are also ways of relating to others. In addition to their socializing dimension, their capacity to symbolically generate roles makes them effective transmitters of society's predominant values and attitudes.

Without doubt, these four dimensions are present in the use of computer games [5]. Studies on the influence of this software are still few in number. We consider that most of the research has focused on three aspects: 1) sociological approach in which the main goal is to describe the use and effects on social development and relationships; 2) effects in learning based on the applications of digital games in school; and, 3) the influence of the use of games in digital literacy.

Sociological approach

Most articles and research reports about the use of video games aims to describe the current use of this technology and to try to analysis the differences in access and gender.

The time that a particular child spends on a computer and their activities on the computer may depend on age, gender, ethnicity, and social class. In a national survey of children and teenagers from 2 to 18, the percentage of children who reported (or were reported by their parents) to have used a computer out of school the day before rose with age: From 26 percent in the 2 to 7 age range, to 44 percent among the 14- to 18-year-olds (Roberts et al., 1999). Interestingly, while more boys than girls reported using (or were reported to use) computers *in school* the day before, there were no gender differences in percentages using a computer *out of school.*

The core audience for computer game systems, such as Nintendo or Sega, has always been boys between the ages of 8 and 14. Boys are five times more likely than girls to own a Genesis or Super Nintendo computer game system. Boys have always and continue to spend more time playing computer games (Roberts et al., 1999). The gender disparity in the amount of time spent playing computer games is greater for 14-18-year-olds than for 8-13-year-olds.

Other evidence suggests a more even gender distribution in non-game uses of the computer. For instance, a recent national survey of teenagers between 13 and 17 years, conducted by the Gallup Organization in conjunction with *CNN/USA Today* and the National Science Foundation, found that although boys were more likely to report playing video games on a daily basis, the same number of boys and girls reported using a computer on a daily basis (Gallup Organization, 1997). Furthermore, both boys and girls reported equal levels of computer usage and expressed equal levels of confidence in their computer skills. In Spain recent studies (Fundación Ayuda, 2002) describes that 3,000 adolescents interviewed, 97 percent declare that knows what video games are. 58.5 percent declare that they play almost daily, 36.7 percent one to two days per week, and 4.8 percent never use video games.

Indeed, the Internet provides certain activities that strongly contribute to a more equal gender balance in computer use. Again, Roberts et al. (1999) data suggest that younger girls and boys (between 8 and 13) use computers similarly except in levels of gaming. When in-school and out-of-school use data are aggregated, there are no gender differences in this age group in the use of the computer for chatting, visiting Web sites, using e-mail, doing schoolwork, or using the computer to do a job. The picture is

similar for the 14- to 18-year-olds, except that older boys visit significantly more Web sites than do older girls.

Despite the trends in other aspects of computer use, computer games continue to be more popular among boys. Because computer game playing might be a precursor to computer literacy, and the belief that computer literacy will be increasingly important for success in society, the "gender imbalance" in computer game playing has been a topic of much recent discussion. Efforts of the software industry to create girl games with nonviolent themes and female protagonists have largely been unsuccessful with the exception of *Barbie Fashion Designe* and more recently with the social simulator "The Sims".

Based on an examination of research on games that girls and boys design and on research on their play styles, and television and reading preferences, Subrahmanyam and Greenfield (1998) proposed that the Fashion Designer was successful because it contained features that fit in with girls' play and their tastes in reading and literature. In contrast to boys' pretend play, which tends to be based on fantasy, girls' pretend play tends to be based more on reality, involving themes with realisticfamiliar characters. Probably similar conclusions can be applied in the case of The Sims.

Applications in school curricula

In this section we examine the impact of computer use on children's performance in academic areas such as math, science, language arts, and writing.

Studies on the application of video games in school curricula concentrate on the impact of the material in the games on learning. In these studies knowledge of material in the curriculum correlated clearly with knowledge used in the games.

On the transfer of material in areas of the curriculum the study by Nussbaum et al. (1999), conducted with 300 children in the fourth year of primary school, is particularly interesting. The team designed a series of games using Gameboy, chosen because 1) most children were familiar with it; 2) it is portable; and, 3) it has an enormous potential audience. The team created a series of adventure games that complemented basic educational items in language and mathematics. Each game was a story that included specific characters and interactions, but all shared certain common basic elements: the way the task was presented and how it was resolved, positive or negative feedback at the end of the task, interaction with rival characters, rewards, and assigning a score.

An important feature of the software is that it includes a self-regulation system, that is, a set of rules that adapt the game and its contents to the user¹s level, which is recorded by the machine itself. The aim is to avoid frustration and boredom.

Forty-six educational video games were designed, covering almost the entire educational program in language and mathematics. In the area of language a single objective was set, namely to support the process of decoding via the development of visual vocabulary, the visual discrimination between letters, and phonological and morphemic analysis: All different strategies for recognizing and analysing words.

In the area of mathematics two broad objectives were set: a) to familiarize the child with the basic structure of skills and mathematical thought; and, b) to learn and apply basic mathematical contents, focusing on the areas of arithmetic and geometry.

The project was introduced in six schools. More than 20 teachers participated, and the sample comprised more than 300 pupils.

Nussbaum's team found the children to be highly motivated from the very beginning — both those who were familiar with this type of technology and those who had no access to it outside school.

The quantitative data show that the tool had a very positive effect on the children who presented the greatest difficulties with reading.

Direct observation of sessions of the game showed that, in general, eight half-hour sessions were required to gain the basic skills required in order to play, obtaining feedback and, at the same time an increasingly broad knowledge of the content.

During the experiment the teachers learned to use the instrument autonomously in their classes within a relatively short period of time (2-3 months). A key factor in the success of the project was the fact that the teachers themselves had the opportunity to use the instrument. Their opinion at the end of the experiment was positive; they considered the video game to be an easy-to-use educational instrument with potential as backup to other teaching material.

Some of the features stressed by the teachers were:

Figure 1: Areas in which video games may contribute to learning.

Digital literacy	**Comprehension skills**
Recognition of computing terms	Comprehension of problem words
	Comprehension of procedures
Recognition of computing operations	Comprehension of the game's instructions
Skills developed via the game	**Academic skills**
Problem-solving strategies in mathematical games	Improvement in results in mathematics and language
Problem-solving strategies in language games	

McFarlane et al. (2002) also assessed the knowledge acquired via the use of video games in primary and secondary teaching. The study was based on teachers' opinions on the limits and potential of video games. Their results reflect that most of the teachers had a very positive view of the adventure games and above all of the simulations. However, in spite of this very positive assessment, they stressed the difficulty of using these simulation games in secondary teaching due to pressure of time and the need to cover the educational program in its entirety.

The requirements of the curriculum were also mentioned by teachers in the studies by Sanger (1997) and the F9 Group (2000). For this reason, it is important to design guides that can explain the merits of games to teaching staff and enable them to use them in a

way that is oriented far more towards the acquisition of the knowledge required by the school curriculum [6].

Another group of investigations stresses the influence of the use of video games in improving students' strategies and procedures. The interest is not focused on learning a particular subject, but on the ability of the instrument to develop learning in general.

One of these studies was by Greenfield (2000) who analysed children between the age of 12 and 16 years, using for the most part adventure games. The main conclusions she reached are listed here:

1. Video games aid the development of strategies for reading three-dimensional images;
2. They help to develop learning through observation and hypothesis-testing;
3. They broaden the understanding of scientific simulations; and,
4. They increase strategies for parallel attention.

Along the same lines, Licona and Piccolotto (2000) consider that video games increase the ability to use symbols, the capacity of self-regulation in aspects inside the framework of the psychology of social learning.

Video games are an interactive environment as different from television as television was from the radio. They represent a new means of communication and have a huge potential for entertainment and instruction. "In the purely physical plane, they normally speed up reaction time and hand eye coordination time but they also allow the children to form and improve schemes in their minds, installing, like a new software, the physical and mental approaches necessary to handle computers and the Internet" [7].

McFarlane et al. (2002) show that most teachers acknowledge that games contribute to the development of a wide variety of strategies that are extremely important for learning: Problem-solving, sequence learning, deductive reasoning, memorizing. In addition, group strategies such as cooperative work and task-based learning can be introduced easily in the setting of a game.

That report also presents an interesting summary of the many areas that the teachers stressed [8]:

Figure 2: Areas of learning in which video games can contribute.

Personal and social development	Provide interest and motivation to learn Maintain attention and concentration Provide interest and motivation to learn Maintain attention and concentration
Language and literacy	Encourage children to explain what is happening Use talk to organize, sequence and clarify thinking, ideas, feelings and events
Mathematical development	Use everyday words to describe position
Creative development	Respond in a variety of ways Use their imagination in art and design music, and stories
Knowledge and understanding of the world	Use early control software to investigate direction and control
Physical development	Fine motor control can be developed with the increased refinement in using a mouse for navigation and selecting objects

As we see, the opinions proffered by the teachers in McFarlane's study in Great Britain coincide with those given by the Chilean teachers interviewed by Nussbaum (see above).

Digital literacy

Salomon (1992) established an important distinction between the effect of learning with technology and the effect of technology itself. When we use the computer to perform a certain activity, this is the effect of learning with technology; the effects of technology refer to the impression that it leaves on the user: That is, the long-term "cognitive residue", to use Salomon's term.

An example may serve to clarify this distinction. Imagine a primary school pupil who is beginning to produce written texts. Suppose that for this activity the pupil uses a word processor. The texts written thanks to the use of this program are the effects of learning with technology. Imagine this pupil uses the computer throughout his/her school career. Writing — that is to say, its forms, the volume produced — seems to be one of the elements that are changing, not only because of the use of word processors but because of other forms of writing such as hypertext and multimedia systems. By supposing that the use of the computer to write has certain long-term effects on the form of organization and expression of written text, we are affirming the existence of effects of technology on learning and cognition.

By supposing that the use of the computer to write has certain long-term effects on the form of organization and expression of written text, we are affirming the existence of effects of technology on learning and cognition.

We believe the same is true of video games. Video games are useful instruments for learning specific strategies and for acquiring knowledge; they also develop the learning that is characteristic of the culture of the information society, and this learning is likely to have long-term consequences. Games can be used to learn a particular content, but they may leave an impression (Salomon's "cognitive residue") on the learners as well. Researchers are now investigating the types of learning that derives from the use of the video games and their possible applications in other areas of study.

We should also remember that video games have certain features of their own that distinguish them from other computer products. The content of the medium — as McLuhan (1998) says — is another medium, since many types of content in video games introduce important modifications. To quote Provenzo "video games are a complex, rapidly evolving form to which most parents and adults pay relatively little attention" [9].

Many computer applications, especially computer games, have design features that shift the balance of required information-processing, from verbal to visual. The very popular action games, which are spatial, iconic, and dynamic, have things going on at different locations. The suite of skills children develop by playing such games can provide them with the training wheels for computer literacy, and can help prepare them for science and technology, where more and more activity depends on manipulating images on a screen.

According to Subrahmanyam et al. (2001), "despite advances in interactive technology and the capabilities of current computer games, the fundamental nature of computer games has remained

unchanged". The current generation of games continue to include features that emphasize spatial and dynamic imagery, iconic representation, and the need for dividing attention across different locations on the screen. Therefore, the nature of the effects of computer game playing that stem from structural features of the medium would likely remain the same — although the strength of the effects on visual intelligence could change with increasing sophistication of the graphics.

In a study of 10-1/2- to 11-1/2-year-olds, Subrahmanyam and Greenfield (1994) found that practice on a computer game (Marble Madness) reliably improved spatial performance (e.g., anticipating targets, extrapolating spatial paths) compared to practice on a computerized word game called Conjecture. Marble Madness involved guiding a marble along a three-dimensional grid using a joystick, skills that are key components of visual spatial tasks.

Not every video or computer game will help develop any or all spatial skills. Computer game playing will only enhance a particular spatial skill if the game utilizes that skill. In principle, skills can only be enhanced by game playing if these skills have reached a certain level of maturation. However, to our knowledge, only one study comparing the cognitive impact of games on children of different ages has been carried out and they found no changes in effects between fifth, seventh, and ninth grade students (McClurg and Chaille, 1987). All three age groups showed improved mental rotation, a spatial skill, as a result of playing two computer games.

Another skill embodied in computer games is iconic or the ability to read images, such as pictures and diagrams. Indeed images are frequently more important than words in many computer games. In

a cross-cultural study carried out in Rome and Los Angeles, Greenfield et al. (1994) found that playing a computer game shifted representational styles from verbal to iconic. In the study, undergraduate students played the game Concentration either on a computer or on a board. Those who had played the game on the computer used more diagrams in their descriptions of an animated computer simulation, whereas those who played the game on a board offered more verbal descriptions. Both iconic and spatial representations are crucial to scientific and technical thinking; these modes of representation enter into the utilization of all kinds of computer applications.

Another skill incorporated in playing computer and video games is divided visual attention, the skill of keeping track of a lot of different things at the same time. Greenfield (1996) explored the effect of video game expertise on strategies for divided visual attention among college students. Divided attention was measured by measuring participants' response time to two events of varying probabilities at two locations on a computer screen. Participants who were expert computer game players had faster response times than novices. Playing an action game also improved strategies for keeping track of events at multiple locations. Overall the study showed that more skilled video game players had better developed attentional skills than less skilled players.

Although this research focused on college students, computer and video game playing could have similar effects on children and help develop the skills for occupations that require expertise in divided visual attention (e.g., instrument flying, military activities, and air traffic control). However, there is no research that actually documents a link between video game playing, attentional skills,

and success in academic performance or specific occupations. Furthermore, much of the research on the impact of computer games on cognitive skills has only measured the effects of game playing immediately after practice, and does not address questions about the cumulative impact of interactive games on cognition.

Instructional design and video game design

Instruction design has been based on rather abstract theories of learning whose general statements cannot really be challenged. Theories as abstract as these cannot always be effectively applied; this is particularly the case with the use of commercial software. Clearly, in the analysis of the designs of commercial products, market considerations are a major factor. One very important difference between educational software and video games is the type of buyer, that is, the person who selects the material.

Educational software is chosen by adults: Teachers and parents. So manufacturers and retailers stress the fact that the products are ideally suited to application in the school curriculum. The program is interesting because it "teaches" a particular subject. Often, sellers also stress the play aspect and say that the pupil/child will learn and have fun at the same time. Nonetheless, the main emphasis is on learning, and not on entertainment.

Video games, on the other hand, are chosen by the players themselves. It is taken for granted that players know that the games are enjoyable, so the message to future buyers is centered on the

story of the game: Everything that the game allows them to do, and the adventure in which they are going to participate. This message is aimed at the user, not at the parent or the educator.

The effect of these differences is not only commercial: It goes further. The design of digital games is much more careful, and much higher quality, than that of many of the educational programs currently on sale. Because of this, we analysed the differences in design of two types of product.

We focused on the research of the group headed by Sanchez [10], reported in the project "Top-Ten: the best multimedia educational materials" and compared them with the studies carried out by Group F9 (1998, 2000) on the favourite video games of children and adolescents.

The "Top-Ten" project compiled the answers of primary and secondary school teachers and students to an online questionnaire [http://www.xtec.es/~jsanchez/socials/ topten.htm]. The subject areas covered by the tasks were geography and history.

The most popular products were:

Multimedia world atlas	Reference material, geography
Clic Sinera 2000	exercises
Euroaventura	Adventure story, based on European geography
History of the world	History
The adventures of Ulysses	Adventure based on the voyages of Ulysses
Living in a castle	Simulation of a medieval castle
Egypt	History
Rome	History

The Louvre	Virtual visit to the museum
The time machine	History

Most of these products are reference materials or history programs with a game-based design. The adventures are based on the life of a central character. As they play, pupils acquire new knowledge in the areas of history and geography.

As for video games, we compiled the answers of primary and secondary school teachers and students to an online questionnaire [http://www.xtec.es/~abernat]. The most popular products were adventures, sports and the simulations.

PC Futbol	Sports
PC Basket	
Golf	
Age of Empires	Adventure
Sims	Simulation
Harry Potter	Adventure
The Pink Panther	Adventure/travel
SimCity 3000	Simulation
Doom	Action
Racing Championship	Action

The main difference between multimedia and video games analysed lies in the focus of the design. All of the multimedia are designed primarily on the basis of the subject matter, while all of

the games are designed around the players. It seems that the final obstacle to games use in schools is a mismatch between games content and curriculum content, and the lack of opportunity to gain recognition for skill development. Many of the skills valuable were recognised by teachers in the previous list.

This finding is corroborated in the literature on game design (Saltzman, 2001). Specialists all agree on the requisites for good design: To have played a great deal; to be aware of the good and bad designs on the market; and, — above all — to think like a player at all times. So empathy is vital in the design of a game. According to Prensky (2001), the following questions are vital to the creation of an effective multimedia program:

1. Is the product fun enough that someone who is not in its target audience would want to use it?
2. Do people using it think of themselves as "players" rather than "students"?
3. Is the experience addictive? Do users want to play again and again?
4. Are the users' skills in the subject matter and learning content of the game — be it knowledge, process, procedure, ability, etc. — significantly improving at a rapid rate and getting better the longer he or she plays?
5. Does the game encourage reflection about what has been learned?

As we said above, the design of the multimedia programs analysed was centred on sequencing content. Constructivist approaches stress the idea that knowledge is not something that can be simply written in a book and transmitted to students; the construction of knowledge is a complex process in which pupils must take part. Designs that incorporate tasks or the resolution of significant problems may be a good starting point for achieving this type of learning. Video games conform much more to this than multimedia programs or other more traditional educational instruments.

Learning environments defined as settings in which the student works on a relatively complex task seem to provide better opportunities to learn and to transfer what is learnt to other situations. Nevertheless, many question marks remain. One major problem is the origin of the learning tasks. What is an authentic task? When is a task motivating? Normally, as Merriënboer (1999) rightly points out, constructivists replace knowledge-based tasks with experience or work-based tasks (in the case of university teaching or in-company training).

Anthropologists Jean Lave and Etienne Wenger (1991) use the term "practice" to discuss how actions are situated in their socio-cultural contexts. Essentially, a practice is an activity that involves skills, resources, and tools, and is mediated by personal and cultural purposes. As Squire (2002) points out, a game like *Civilization III,* which involves analyzing geography in order to determine the best geographic location for a city, negotiating trade deals with other civilizations, and making taxation and social spending decisions, comes closer to the kind of meaningful practices educators would like to produce.

Socio-cultural psychologists proposed *Activity Theory* (see Figure 3) as one theoretical framework for understanding how human activity is mediated by both tools and cultural context (Engeström, 1987; 1993). For an Activity theorist, the minimal meaningful context is the dialectical relations between human agents (subjects) and that which they act upon (objects) as they are mediated by tools, language, and socio-cultural contexts (Engeström 1987; 1993). Subjects are the actors who are selected as the point of view of the analysis. Objects are that "at which the activity is directed and which is molded or transformed into outcomes with the

help of physical and symbolic, external and internal tools" [11]. As such, objects can be physical objects, abstracted concepts, or even theoretical propositions. Tools are the concepts, physical tools, artefacts or resources that mediate a subject's interactions with an object. The *community* of a system refers to those with whom the subject also shares transformation of the object; the cultural-historical communities in which a subject's activity is situated.

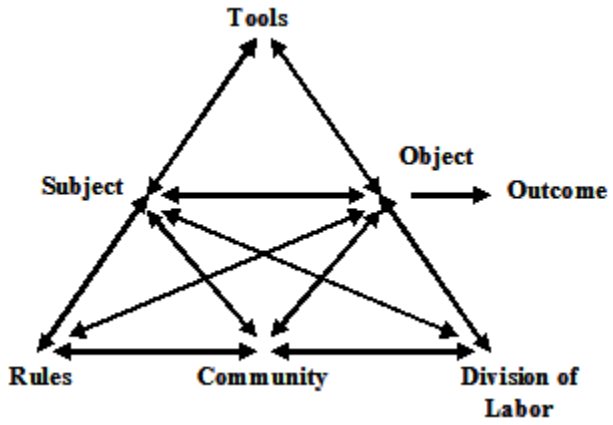

Figure 3: Visual depiction of an Activity system.

Activity Theory offers a theoretical framework with strong intuitive appeal for researchers examining educational games. Growing out of Vgotsky's discussion of the mediating role of artifacts in cognition (1978), Activity Theory provides a theoretical language for looking at how an educational game or resource mediates players' understandings of other phenomena while acknowledging the social and cultural contexts in which game play is situated. Learning is conceptualized not as a function of the game itself — or even a simple coupling of the player and game; rather, learning is seen as transformations that occur through the dynamic relations between subjects, artifacts, and mediating social structures.

According to Squire (2002), activity theory provides a theoretical language for looking at how an educational game or resource mediates players' understandings of other phenomena while acknowledging the social and cultural contexts in which game play is situated. Learning is the product of the relations between subjects, artifacts, and mediating social structures.

In summary, we consider that the design of video games raises a number of crucial aspects that should be borne in mind in the design of educational multimedia. The technical side seems to be particularly important: User-based design, the use of practice and constant feedback, goal-directed learning, learning by discovery, creating identification and empathy with history and with historical characters. Nonetheless, there are still a number of unresolved questions, among which the following stand out:

Design issues

Cognitive designers have centered the sequencing of educational computer programs on the *contents;* in the constructivist approach the problem is to design the sequence of *tasks* that the students should perform. As Collins et al. (1989) state "the ability to produce a coherent, appropriate sequence of a case (for example, a learning task) is the key in the design of constructivist learning environments".

The solution proposed by the majority of constructivist authors for the problem of sequencing tasks is the same as that adopted by the cognitivists with respect to content: They suggest grading them from simple to complex. So the criticisms of the problem of grading contents are repeated here as well. As Merriënboer (1999) rightly states, this is a problem that depends not only on the type of task

but also on the context. But some examples suggest the opposite. Merriënboer demonstrates this very well with the case of training students in the design of instructions. A student does not learn to apply the theories of design before gaining a global vision of what a design is, without having seen materials — without having a general vision of the problem.

Outcomes issues

All constructivist theorists appear convinced that learning in context with authentic tasks improves transference and helps students to apply what they learn in the school environment in other contexts, and *vice versa.* However, this claim is not easy to demonstrate and in fact we do not think that it has been conclusively established in the research into the consequences of the design of multimedia and Web materials on learning. Nor has the transference of the use of the games into other types of context been satisfactorily proven. This is an area that remains of great interest in educational research.

Curriculum issues

The greatest difficulty facing the use of video games at school lies in the fact that teachers must try to find room for the game inside the course syllabus. This is a point that the producers of this type of software should perhaps consider. Games, especially adventures and simulations, require several hours and it is sometimes not easy to adapt them to rigid school timetables. Introducing pre-scenarios in the simulations appears to be a good start: That is, working with much more simple models or subparts of the program that allow teachers to illustrate and manage the main concepts of the

simulation. These scenarios can be edited by the teachers so that they can prepare the materials beforehand.

Pedagogical issues

Another important aspect is the adaptation of multimedia materials and games to group work for use in schools. Users should be able to save their results progress made with the names of more than one player and there should be a record of the activities carried out by the pupils. This would enable teachers to follow the strategies adopted during the game more closely than at present.

Improving some of the design problems of commercial video games would also make it easier to adapt these programs to the school environment. In spite of these limitations, the market offers a wide variety of products which can be incorporated in teaching without much difficulty and which, as we have stressed throughout the article, offer real educational possibilities.

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Notes

1. Prensky, 2001, p. 56.

2. *Op.cit.,* p. 59.

3. *Op.cit.,* p. 61.

4. Bishop, 1998, p. 9.

5. When we speak of computer games we should remember that not all video games are the same. In general, there are seven categories: Action games that usually depend more on eye to hand coordination than on the content of the game (Tekken, Mortal Kombat).

Strategy games that stress the importance of logical thinking and planning (Age of Empires).

Adventure games that usually involve exploration and problem-solving (Indiana Jones).

Role play games, similar to the adventure games but instead of focusing on resolving enigmas they depend on the evolution of the characters. They are also called MUDs (Multi user domain) because they can played on line with a number of players at once. (Final Fantasy VII).

Sports games that simulate basic strategies from individual or group sports (Golf, PCFutbol).

Simulators, which recreate an object or process in great detail (SimCity 3000).

Classic games, normally computerised versions of well-known board games (minesweepers, solitaire)

6. See the section on "Teaching resources" coordinated by the Group F9 in the *Revista Comunicación y Pedagogéa* in which, since the year 2000, each issue has contained a description of how to use a particular video game in teaching.

7. Kerckhove, 1999, p. 52.

8. McFarlane, 2002, pp. 13-14.

9. Provenzo, 2000, p. 109.

10. Teaching and Multimedia Group, Autonomous University of Barcelona.

11. Engeström, 1993, p. 67.

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