SAE Institute
(Middlesex University)

Effectiveness of Interactive Multimedia for Children with Special Educational Needs

Educational games and their effect on children's motivation

Dissertation

BA (Hons.) Multimedia Arts

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Abstract

This research investigates the benefits of educational multimedia games for children with Special Educational Needs (SEN).
The study focuses on three key elements in an educational multimedia game, and what role they play in motivating the children. These key elements are ‘an engaging story’, ‘identifiable characters’, and ‘meaningful feedback’.
These elements are incorporated into a prototype mathematics game, which is then tested on four primary school children who attend a mainstream school as opposed to a special needs school. The content and appearance of the game were specially modified for the particular target group to encourage the children to learn mathematics in a fun way.
The qualitative observation and analysis of the children’s responses indicates that interactive multimedia can offer an entertaining learning experience for children. The motivational factors tested in this research have encouraged a positive response on the children’s confidence and engagement in learning.

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Ayhan, Earl, Tatenda and Shakeyra.

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1. Introduction

Digital media has penetrated a child's daily life in a variety of forms, with many children now having access to video games and the Internet.
According to a Becta (British Educational Communications and Technology Agency) survey on the use of computers at home (Becta and DfES 2002c), 81% of households have computer access. Both children and parents reported that the use of computers could have a beneficial effect on education and development. Parents feel that computers have helped, or would help children to achieve a better result in school study. Children feel that computers make schoolwork more enjoyable and fun. However the survey reports that the ownership of computers strongly relates to social grade and income of the household. This suggests that it is important that computers must be accessible for all children at school, so that socially disadvantaged groups are also part of the digital revolution.

Children enjoy learning with computers, and the Information and Communication Technology (ICT) has helped in some areas in their improved performance and attitude at school (Becta 2003). The average number of computers in primary schools has increased from 13 in 1998 to 31 in 2002, and the percentage of primary schools connected to the Internet has increased from 17% in 1998 to 99% in 2002 (DfES and National Statistics 2002).

Multimedia technology has a distinctive advantage over traditional learning methods. Text, sound, static images and moving images can be presented simultaneously, and several traditional media elements can be combined into an interactive environment. The question arises whether the benefits of multimedia technology can be used to help children with learning difficulties, and how multimedia could be used to help enhance the learning development of such children.

According to Department for Education and Skills, “up to 20% of school children may need special educational help at some stage in their school careers” (DfES 2001). This indicates that there is a need for specialised applications and an understanding of educational content for children with Special Educational Needs (SEN).

2. Research questions and the aim of the study

The focus of this research is to study what motivational elements are used and implemented into multimedia education. The use of story, characters, and interactive feedback are the three motivational factors that are considered as research priorities. They are the fundamental elements that provide an enjoyable learning experience for the child.

Research questions:
1.Do story, characters and feedback motivate children?
2.Do the motivational factors have any affect on children with SEN?

A prototype shopping game was developed for children with SEN. Because of the broadness of the term SEN[1], the target group of this study was narrowed down to children who attend a mainstream school, and were considered to have moderate learning difficulty[2]. The aim of the prototype is to provide a fun environment for the children to practice basic mathematical skills involving money, and to boost their confidence in learning.

Four primary school children, age 10 years old, who were considerably slow in their mathematics learning development, tested the prototype game. The main objective of the prototype testing was to observe the children's responses and level of engagement with the story, the characters, and the feedback elements. It is not a goal of this research to find evidence of long-term learning improvement and the effectiveness of the educational game because of the short research period.
The usability for children factors of the game was a concern during development, and implemented as much as possible. However, a comprehensive usability test was not conducted due to limited resources.

[1] See appendix A-1: Definition of SEN; Categories of SEN
[2] See appendix A-2: Description of Moderate Learning Difficulty (MLD)

3. Background

3.1. Children and Educational games

Children naturally enjoy using the Internet and computer games, and more children have started to use computers for learning purposes both in school and at home (Becta and DfES 2002c). It has been reported that the use of computers in school curriculums has been beneficial for children. The subjects are mainly literacy, science and mathematics (Becta and DfES 2002b). In the case of learning mathematics, computers help to "develop mathematical vocabulary, logical thinking and problem solving skills" (DfEE 1999, p.31). However, it is important to recognise that children and adults tend to be fundamentally motivated to use a computer in different ways. Enjoyment is the top priority for children, as opposed to adults who use computers as a necessity. Educational software has to be fun for children to interact with to expect a positive learning outcome (Inkpen 1996).

As a part of the field research, two popular educational games; 'Zoombinis Maths Journey' (TERC 2002), and a website 'Grid Club' (4 learning *et al.* 2001a), were reviewed at the BETT exhibition[3]. The common characteristics found in both games are:

- Friendly characters
- Colourful graphics
- Sound effects and music
- Plenty of feedback
- A storyline for activities
- Reward elements
- Selection of challenging tasks

Previous research on educational multimedia content (Chamberlin 2003; Sedighian and Klawe 1996) has suggested that these elements help to make learning a fun experience for children, so that they are motivated and voluntarily spend time in learning. Also in the research, a user-centered approach in the design is recommended for computer programs to have a positive effect on

[3] BETT: The Educational Technology Show, 8-11 January 2003. Olympia, London.

children. Druin *et al*. (1999, p.51-71) have taken the user-centered approach further by incorporating children in the design team, and have developed successful prototype drawing software.

3.2. The E-GEM project

A large part of this research is influenced by the literatures of the Electronic Games for Education in Math and Science project (Conati and Klawe 2000; Klawe 1998; Sedighian, K. 1997; Sedighian, K. and Sedighian, A. 1997a; Sedighian, K. and Sedighian, A. 1997b; Inkpen 1996; Inkpen *et al.* 1996; Sedighian, K. and Klawe 1996), which is a collaborative long-term research project centered at the University of British Columbia.

One of the E-GEM researchers Sedighian,K. developed an educational puzzle game called 'Super Tangrams'. The aim of the game is to motivate children around 11 years old to learn mathematics in a fun way. The research reports that "computer games can provide a motivating mathematics learning environment for children" (Sedighian, K. and Klawe, M. 1996), and the participating children responded positively to brightly coloured graphics, sound effects, and having background music (Sedighian, K. and Sedighian, A. 1997a; Sedighian, K. and Sedighian, A. 1997b; Sedighian, K. and Klawe 1996).

The children were asked to write a journal during the trial period, and many showed that they were enthusiastic and enjoyed the time spent on playing the game, at the same time they recognised that the game content was clearly mathematical. The game helped to change the children's attitude towards mathematics, and the children learnt quite complicated mathematical concepts after playing the game regularly for several months (Sedighian and Klawe 1996).

3.3. Multimedia for children with SEN

The main advantage that multimedia can provide is interactivity, which one-dimensional learning, such as traditional textbooks, cannot offer. Children can learn at their own pace within the computer environment by seeing, hearing and practicing. The question is whether these benefits can be seen with children with SEN. Hasselbring and Glaser (2000) report that the combination of visual images and sound together help children with SEN to gain conceptual understandings of information, which is difficult to comprehend with text alone. Sedighian (1996) also found that the 'Super Tangrams' game had positive effects on confidence among low achievers of mathematics in the class, although the game was not specially designed for such children. It indicates that a well-designed educational game that focused on motivation can encourage any child's learning ability, and improve learning development.

However, Hillage (2000), of the British Dyslexia Association Computer Committee, points out that many dyslexic learners with difficulty in learning mathematics are affected by anxiety. Children with SEN, particularly those who attend mainstream school are aware of their slow learning development in comparison with other children of the same age, so that the emotional support for these children is essential. Hillages' (2000, p.7) view is that computers are beneficial for such children; they give "immediate feedback, without criticism or judgment, which may arise in the classroom".

Also at the BETT exhibition, some of the educational software that targets children with special needs in mathematics (Neptune ca.2002; Resource ca.2002; Spa ca.2002; White Space ca.2002) were reviewed. All had clear learning goals and colourful interfaces but the quality of the graphics and sound were very poor in some cases. It was evident that the software was developed for children with severe learning disabilities, who may have physical disabilities or severe cognition problems, so the interface and activities were designed to be extremely simple. However, for children who have a reasonable degree of conceptual understandings in general, poor graphics can be discouraging and may be perceived as juvenile.

Mainstream educational games and websites are visually attractive and age appropriate, but the content is not suitable for the ability of such children. Specialised software on the other hand has a focused learning outcome, but may not provide enough motivation to engage with the activities because of the appearance.
For these children to benefit from multimedia learning, it appeared there was a gap to be filled in the currently available educational multimedia games and software.

The prototype ‘JB game’ developed for this research was designed to motivate children by incorporating an engaging storyline, identifiable characters and providing meaningful feedback throughout the game. The age appropriateness was also considered, as well as suitable content design for the children’s learning abilities and goals. However the aim of the ‘JB game’ was to encourage children to gain confidence and improve attention span, before achieving learning goals.

4. Prototype development

4.1. Description of the 'JB game'

The prototype 'JB game' is designed for Key Stage 2 children (7- 11 years) who have difficulties in acquiring basic mathematics skills, especially with problem solving involving money. The final delivery format is cross platform CD-ROM.

It is a shopping game, in which the user helps the main character 'JB' buy jellybeans from three different shops. The activities are simple calculations of addition and subtraction using 1p, 2p and 5p coins. The game activities are set to Key Stage 1 in the National Numeracy Strategy[4] (DfEE 1999, p68-69). The mathematical learning objectives were consulted with primary school teachers. The tasks become slightly more complex as the user progresses from shop to shop[5].

4.2. Scope of the prototype game

The development of the 'JB game' prototype focuses on incorporating an engaging story, identifiable characters and meaningful feedback into a design to be tested by children. The aim is to investigate the effectiveness of the motivational factors in the multimedia learning environment.

There are two areas, which have to be compromised in order to prioritise the focus of the study.
Firstly, exploring various programming techniques is out of the scope of this study, although the codes will certainly be reviewed in the future to make the program flexible and expandable. The current prototype is designed for relatively fast computers (800mhz to 1ghz) to take an advantage of the media rich content. There are technical issues with the sound and animation, which need to be optimised for the best possible performance if the game were to be distributed to a wider audience, including those who have lower specification computers.

[4] See appendix B: National Numeracy Strategy Excerpt
[5] See appendix C-1 to 4: Prototype Game Flowchart

The second is the implementation of an effective teaching method, which is not considered as top priority of this study. The game activities and learning objectives were designed while interviewing primary school teachers and referencing the National Numeracy Strategy (DfEE 1999). However the research assumes that it would be necessary to revise the educational content for further development.

4.3. The story

JB, the main character of the game, wants to grow jellybean trees, which grow from jellybeans. JB needs to go to the shops to buy some beans but needs some help, as JB is not good at counting money. JB and the user will go to three shops to buy some jellybeans. After shopping, JB takes the jellybeans home and sends a thank you letter to the user with a picture of the jellybean trees growing.

The story is simple, yet it has an important role to set the scene at the beginning of the game, and to bind the scenes together as a whole. An interesting storyline can keep a child's interest level high, and makes the activities meaningful. It can also incorporate a reward element in a story.
Both the 'letter from JB' and the 'picture of the jellybean trees' at the end of the game are rewards for playing the game successfully.

4.4. The characters

The characters are the bridge between the user and the game objective, and they are designed to support and encourage the children's activity by being cheerful and entertaining. JB and the shop owners are jellybean creatures; the fantasy characters allow the graphics to be more vivid and colourful than real life.

JB, the main character (fig.1) does not have confidence in counting money, so s/he seeks the users help. S/he cheers when the user is successful with a task, and encourages when the user gets an answer wrong.

JB is always on the user's side, as s/he sees the user as a friend. The look of the character is deliberately designed to be sexless, so that both boys and girls can relate to the character with their own preferences and imagination. As the prototype is aimed at both genders, the look and feel of the game should not be too boyish or girlish. It is particularly important that the design of the main character acts as an agent between the child and the game activities.

Ms. Red, the owner of the Red bean shop (fig.2) is kind and helpful. She greets the user nicely, and gives helpful comments to guide the user to the correct answer. Mr. Yellow, the owner of the Yellow bean shop (fig.3) is cheeky and friendly. He also helps to guide the user to correct answer. Mr. Blue, the owner of the Blue bean shop (fig.4) is the exception. He is a grumpy character who doesn't give the user help. As the user visits Mr. Blue's shop last, Mr. Blue gives the user a challenge to solve the problem without help.

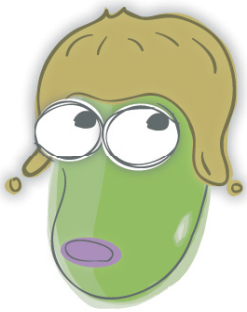


Fig.1.
Character JB

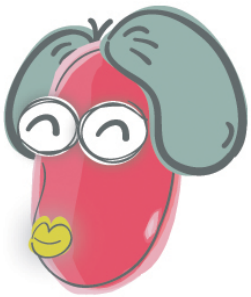


Fig.2.
Character Ms. Red

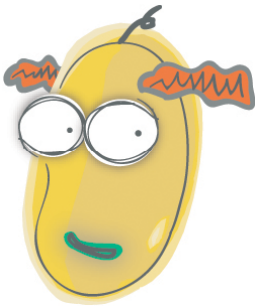


Fig.3.
Character Mr. Yellow

Fig.4.
Character Mr. Blue

4.5. The feedback

Feedback, such as sound effects, animation and dialogue, are useful as a response to user action or answers. Feedback is the one of the main advantages that interactive multimedia can offer. A variety of feedback elements are provided throughout the game to help engage and encourage the user (fig.5). It is important that when feedback is used in educational content, it has to be useful and meaningful, as well as entertaining, and should not unnecessarily distract the user's attention.

In this prototype, non-speech sound, animation, and dialogue are incorporated as:

1. Response to user action
2. Response to user's answer
3. Indication of changing of the scene or activity
4. To differentiate characters

Non-speech sound is thought to enhance the users performance. For example, a video game player scores more points with sound effects than without (Dix *et al.* 1998, p.562). The sound effects for the coins and jellybeans were real sound recordings, since they are the only objects in the game that the user interacts with as real objects.

Animation represents actions better than static images (Dix *et al*. 1998, p.598). Animation was also used to support user interaction in the prototype. The jellybean objects were animated when the user interacts with them which reaffirms the story environment and user actions.

Special attention was paid when designing the feedback response to a user's wrong answer. It is extremely important that children do not feel that they are judged or humiliated when an answer is wrong. It is expected that children would get answers wrong, perhaps many times, in the case of the user group of this study. In the 'JB game', variations on the 'try again' phrase appears randomly so that the same phrase is not repeated frequently.

	Sound	**Animation**	**Dialogue**
Response to user action	Click on coins Click on buttons Grab and drop jellybeans Ring a bell	Coins dimmed when clicked Highlighted buttons	
Response to user answer (Correct answer)	Cheer sound	Happy face	'Yippiee!' 'Well done!'
Response to user answer (Wrong answer)	Disappointment sound	Sad face	'Oh, never mind.' 'Try again.'
Change of the scene or activity	Transition Sound of coins dropping in the money jar	Transition Coins move into the money bag Jellybeans move into the bean bag	Shall we go?'
Differentiate characters	Unintelligible abstract voice for each character	Variety of face expressions	JB: use children's language Ms. Red: polite Mr. Yellow: friendly Mr. Blue: grumpy

Fig. 5. Examples of the feedback used in the prototype

4.6. Other supportive elements

4.6.1. Colours

Children respond positively to a colourful interface. A study found that most children think that the learning element of an educational game is more important than colourful graphics, but the graphics helps to make the activity enjoyable, and adds "flavor to the learning activity" (Sedighian, K. and Sedighian, A 1997a). Vivid primary colours were used for the characters and interactive objects.

In contrast, softer neutral colours were used for the background and other graphics to differentiate between interactive and non-interactive objects.

The colours also relate to the game levels, and are associated with scenes and characters, and helps to provide points of reference within the game.

4.6.2. Realistic objects

The story and the characters create a fantasy world, however the graphics of the coins in the game are intentionally designed to look realistic. The relative size and image of the coins accurately represent coins in the real world. This is to support the learning goal of the game, which is to acquire problem-solving skills involving money in a real-life context.

4.6.3. Music

Background music helps to set the mood and tempo of each scene. The use of music with sound effects are established features in mainstream game production (Pidkameny 2002; Prince1996). Sedighian (1997b) reports that music doesn't interfere with the child's learning, but helps them "think better". The music chosen for the prototype is relaxing, and is intended to slow the children down. The exception is the Blue Shop, which has slightly up-tempo music for the last stage or climax of the game, and suits the 'mean' shopkeeper character. The volume of the background music is set considerably lower than the sound effects, so that the user is not distracted, and the game play interaction is prominent.

5. Prototype test

5.1. Prototype test overview

The study was conducted with two prototype game tests, both at Kingsmead Primary School in the London Borough of Hackney, where the test participants attend everyday. L. Stapleton, the ICT teacher of the school, facilitated the test. The school dining room, which was the only room available in the school, was not the most ideal environment for the test, but it was important to use a familiar location for the children to feel comfortable (Druin *et al.* 1999) so that their natural behavior could be observed.

The observation of the test was recorded in a logbook by a researcher, who also interacted with the children during the test. Both tests were also recorded on video for later analysis; unfortunately it failed to capture a large part of the second test due to technical problems.

The usability for children was taken into consideration during the development of the prototype. Any usability issues to arise during the first prototype test were recorded, and modifications needed were reflected in the second prototype. However, a comprehensive usability test was not included because of the limited human resources of this research.

5.2. The participants

L. Stapleton selected four children (one girl and three boys) age10 years, to participate in the test. They were considered to have special educational needs and have problems with basic mathematical skills such as placing value, recognising numbers in a number system, addition and subtraction. The general characteristics of the children's learning abilities according to L. Stapleton are as follows (questionnaire, 30th September, 2003).

Ayhan (boy. fig.6)	Difficulties following instructions
Earl (boy. fig.7)	Low confidence
Tatenda (boy. fig.8)	Disruptive and low attention span
Shakeyra (girl. fig.9)	Well below average

The same children participated in both the first and second prototype test. Having a small number of subjects was appropriate for the nature of this research and its scale. It enabled the children to be closely observed, and also helped to form a relationship between the researcher and the children.
As the Kingsmead School encourages the use of computers in school curriculums, all children have used a computer in the classroom. Tatenda is the only one that has a computer at home, and regularly uses the Internet.

Fig. 6. Ahyan

Fig. 7. Earl

Fig.8. Tatenda

Fig.9. Shakeyra

5.3. Procedure

The children were told that the researcher needed their help to make a better game. This was to encourage the children to express their opinion without reserve. (Druin *et al.* 1999)

A lap top computer (Windows XP, 1.2 Ghz with 112MB RAM) and a mouse, which the children use for their class activities, was allocated to each child.
In the both occasions, the children were asked to start playing the game without given instruction. The researcher did not interrupt the children until they had finished the game sequence for the first time. The reason was to observe how intuitive the interface is, and how the children find solutions by themselves.
Once the children completed the game, a short casual interview took place for 2 to 3 minutes, and the children were asked to play the game again. The researcher sat with the children the second time round, and asked them questions as the children played the game.

CD-ROM's of the game were sent out for evaluation with a questionnaire[6].
One evaluator was the teacher L.Stapleton, who selected the participating children at Kingsmead Primary School. The other teacher, who had no prior information of the prototype, and works at a different primary school in London, also evaluated the game.

5.3.1. The First Prototype Test (8th July 2003)
One game sequence (the red game) was prepared for the first test. The overall storyline of the game was not provided, just the opening phrase from the character 'JB', "Can you help me go shopping?".
The interface was not finalised at this stage. The key objectives of the first test were:
- To observe how children interact with the characters.
- To find any usability issues with the interface.
- To observe how the children engage with the activity without sound and storyline.

5.3.2. The Second Prototype Test (8th September 2003)
The second test was done two months later. The game was the completed version, which has three shops to visit, with an introduction and end sequences,

[6] See appendix D: JB Game Questionnaire

accompanied by sound effects and music. Some graphics and interactivities were modified based on the first prototype test findings.

The main objective of the second test was to observe whether the motivational factors 1) Story, 2) Characters, 3) Feedback; have any affect on encouraging and engaging the children. Any difference in the children's response from the first test were also observed.

6. Observation and analysis

6.1. Observation Overview

Over all, the children seemed to enjoy the game in both the first and the second prototype tests. Positive body languages were observed while they were playing the game, particularly with the second prototype. The children preferred the second prototype because of the music and the sound effects.
In both occasions, all the children completed the game without giving up, and were keen to play again as soon as they had finished.

6.2. The first prototype test

The session lasted for 1 hour and 30 minutes, including a discussion and interview with the children. It took the children 5 to 8 minutes to complete the game sequence and they played the game at least 7 times during the session, except Tatenda. Tatenda was the fastest to complete the game, yet looked the least keen on playing.

Ayhan, Earl and Shakeyra said that they liked JB, and thought the character's age appropriateness was just right. Tatenda did not seem to be interested in the character. Two children thought JB was a boy, and other two thought it was a girl. None of the children could give the reason, however it was interesting that Shakeyra, a girl, thought JB was a boy, where Ayhan a boy thought it was a girl.

> "I'm beginning to like him (JB) already." (Earl)
> "I think JB should have a very gentle voice, because he is very gentle." (Earl)

Earl expressed special interest in JB. He always chose to let JB try first in the red jar scene and giggled when JB got the answer wrong, then he would lean forward when his turn came. The concept of helping JB seemed to encourage Earl in particular.

There were some problems with the interface. In the first prototype, proceeding to the next scene was timed instead of incorporating a 'next' button. This was problematic in several occasions, that the children felt it was too long to wait, or not enough time to read the text on screen. A solution was to use a 'next' button with a flashing arrow animation in each the steps to proceed to the next stage.

It took time for some children to realise that they could grab the jellybeans at the shop scene, because there was no obvious indication when the users cursor was over the jellybeans. It was modified for the second prototype, so that the jellybeans animate when a cursor passes over them. It was expected that some children might find it difficult to drag the object on the screen, since a previous study (Inkpen *el al.* 1996) indicated that the children performed better with point-and-click method. However, it did not appear to be a problem with any of the children, probably because they are used to using computers at school, and the distance that the child has to move the object was kept as minimal as possible. But this could be an important usability issue with children who are not used to computers.

"I know! I just have to pick the smaller ones. " (Ayhan)

"I just clicked anything, and got it right. " (Sharkeyra)

After playing a few times, Ayhan noticed that it was easy to pick a correct jellybean (red shop) because the correct jellybean was always smaller in size (fig.10). He looked satisfied with his discovery, and started to pick the smaller jellybeans without thinking from then on.

Shakeyra's comment also indicated that she was not engaged with mathematical activity, but excited when something happened on screen.

It became clear that there was a problem with the activity design, which made the leaning objectives meaningless. The red shop activity was later revised for the second prototype. The size of the jellybeans were made identical, and the price of the jellybeans were made to have more variety so that it forced the children to think of the mathematical problem, and not automatically click through the game (fig.11).

"Do you have any other games with you?" (Tatenda)

"I can't wait to play the rest of the game." (Ayhan)

"I'm looking forward to see JB again." (Earl)

Tatenda said he liked the game but it was too short. He seemed to be bored after he played it a couple of times. It was apparent that the children enjoyed the game and liked the characters, and they wanted more, which was an encouraging result, and helped the development and improvement of the game for the second prototype.

Fig.10. The first prototype screen. The jellybeans were two different sizes and prices, which made it too easy to pick the correct one.

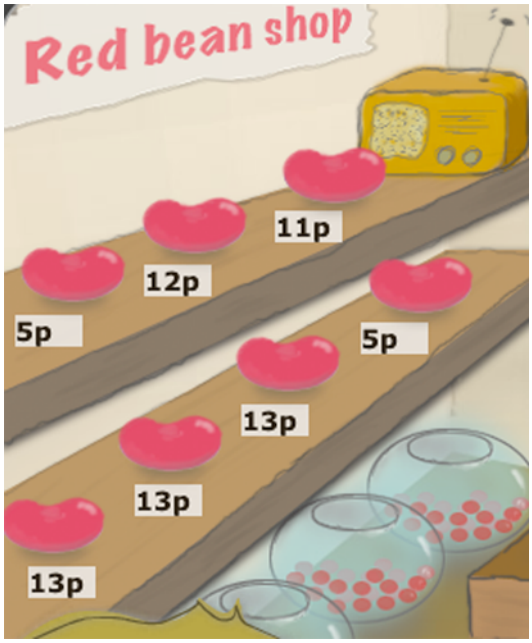


Fig.11. The second prototype screen. The prices were changed to be more varied, and the jellybeans were made to be identical in size.

6.3. The second prototype test

It took 20 to 23 minutes for Ayhan, Earl and Shakeyra, and 12 minutes for Tatenda to complete the whole game. Unlike the first test, Tatenda seemed to engage with the game play. All the children said they enjoyed the second prototype more than the first, because it had sound and music.

They agreed that they would like the characters to speak, but at the same time they either liked or enjoyed reading text on screen even though Earl and Shakeyra were slow readers. Ayhan, Earl and Shakeyra were reading out loud, and they skipped the words they could not read. If the instructions were given in audio format, as well as text, it would maybe help the children with reading difficulties get more from the game.

Ayhan, Earl and Shakeyra were excited when JB asked their name. Incorporating the childs name into the game helped to make the experience more personal. They were also excited when they reached the end screen with a letter from JB, to see the letter with their name on it. They compared each other's screen to see what it said on the letter and how many jellybean trees they got. Tatenda did not show excitement with the storyline and almost ignored the letter; he was more interested in how quickly he could complete the game. Earl and Shakeyra seemed particularly engaged with the storyline, they both liked the idea of helping JB, and receiving a letter from him at the end.
As they played the game for a second and third time, they were looking forward to see how many jellybean trees they were going to get. The number of jellybean trees that appear in the picture is different each time the game is played, as it depends on how many jellybeans the user helps to buy in the game. This motivated the children to play the game more than once.

The new interface had arrows to click to proceed forward so that the children could control the speed they played. However there were some issues with the interface and activity design.

"I don't remember the question." (Ayhan)

Ayhan was stuck during the yellow jar sequence, which required the user to add the left over coins to work out the total, which is slightly different from the other jar sequence. He assumed that the task was the same as before, and did not read the instruction. This indicated that the user needs to be able to access instructions at any stage of the game. Also the interface should have an intelligence to be able to remind the user. Particularly with a child like Ayhan,

who has problems in following instructions, and would benefit with a reminder feature.

"Can I go to the blue shop now?" (Ayhan)

"Do I have to spend all my money?"(Tatenda)

Ayhan had just finished the yellow jar scene, and a map on the screen indicated for him to go to the yellow shop, however he wondered if he had a choice. In the yellow shop, the user was asked to spend all of the money that they had, and the task was to work out how many jellybeans the user can buy. Tatenda tried to buy fewer jellybeans and the amount of money he paid was correct. Then he realised why he was told to try again because he didn't spend all of his money. Both Ayhan and Tatenda's comments support Chamberlin's guideline (2003) that children want choice and control. The game progression was linear, and the user was not given a choice, and also the activity was not flexible enough to fulfill the children's requirements. In educational games, it is important to direct children to achieve a learning outcome. In this case it caused the game structure to be rigid, and choice and control were taken away from the user. It gives an insight to the future development of the game, that the empowerment of the children is equally important as achieving a learning outcome.

6.4. Individual analysis

Ayhan

Ayhan interacted with the interface impatiently, and clicked buttons repeatedly and rigorously. While the screen was loading a new scene he clicked anywhere on the screen trying to get a response. Some of the problems he encountered were because he did not pay attention to the instructions. Although his body language was lively and positive, he did not seem to be interested in why he was repeatedly getting wrong answers. This highlighted that the game design needed to be reviewed to understand the impatience that children with special needs may have.

Earl

Earl was particularly enthusiastic about the game and the character JB from the first test. Before he began the second test, he said that he had been thinking about the game during the summer holiday. According to L. Stapleton (personal communication 8th July 2003) his learning difficulty is severe compared to the other participating children, and his confidence is low. Earl was slow in reading the instructions, and took time to complete the tasks. However he looked confident and happy while playing the game. It was remarkable to observe that Earl was the first child to start helping the other children to solve problems.

Tatenda

At the first test, he was not engaged with the game. He played once, and then asked if he could go on the Internet, and was told that is not possible, but he can play the game again if he wishes. He played twice more and wanted to go back to his class.

It is difficult to access Tatenda's response, since most of his answers in the interview were "It's OK", and his body language such as slouching and fidgeting, suggested that he was unmotivated. However, it is not fair to say that he was not enthusiastic, or did not like the game. At the second test, he was keen to play the game many times, as soon as he finished one round. He also played the game the fastest of all the children, and kept looking at the other childrens screens to compare his progress. He seemed to be proud of himself that he was ahead of the others.

Shakeyra

Shakeyra was interested in technology, and was curious about the video camera, which was recording her activity during the tests. She was animated when she talked about computers and cameras. During the interview, she mentioned that she was not happy in her classroom because she does not get much chance to work on computers as the other classmates always take over the computers.

Shakeyra had problems particularly with subtractions (ie. work out the change), she did not understand the questions and could not give a correct answer without help.

6.5. Teacher's evaluation

Both the two teachers who evaluated the game valued the storyline and the reward element in the game. Both thought the characters were appropriate for the age group, and the friendly faces were likeable. They recognised that the background music could be destructive in some educational games, but the music used in the prototype gave children "the points of reference in the game and helped to recall strategies" (L. Stapleton, questionnaire, 30 September 2003), which supports Sedighian's (1997b) research findings on motivation effects of background music in games.
The other evaluator C. Harrison (questionnaire, 28 September 2003) mentioned that it is important that the sound effects are not intrusive, especially for the teacher, and the prototype sound effects were just right. Also the speed of the animation and the game was adequate so that the "children had time to take it all in".

There were recommendations on improving the interface such as larger buttons with brighter colours, and speech instruction for non-readers. For the activity design, the questionnaires indicated that more attention was needed on how to make the children understand the questions when they get answers wrong.

6.6. Summary

The most positive attitude that was observed during both prototype tests was that the children helped each other to solve problems. One can assume that such behavior may not be so apparent in mainstream school classroom activities, where slower children are often left behind. The game was intuitive enough for children to work out by themselves, which helps them to feel empowered and independent. However from the qualitative observation, it is recommended to have a supervisor to monitor the child's progress on the particular problems.

The positive body language, such as leaning forward and cheering with JB, indicated that the children were actively involved with the game. The second prototype was clearly preferred by the children. The sound effects and music

added an entertaining element to the game. Having a storyline, a variation of characters and personalisation helped to engage them with the game play. The look and feel of the game and the characters seemed to attract both the boys and the girl. Although more quantitative data would be necessary to clarify the point, it could be an indication to consider that the look of the JB is cross gender, and both boys and girls can relate to the character.

During the prototype tests, all children completed the game without giving up, which could indicate that the game had some positive affect on children's attention span. However, it is difficult to estimate the degree of engagement over a long period of time. It would need extensive further testing to assess the impact on the children's learning ability. For long term testing some form of non-linear narrative and interface would need to be designed, which would give more choice to the user, and keep the children motivated to play the game repeatedly.

The prototype test found several usability issues with the interface and some problems with the activity design. Usability and activity design are not obviously visible elements for children, but are important issues when designing interactivity for the particular user group of this study. With an intuitive interface children should feel empowered and confident while they interact with the game, otherwise it could cause the children to feel less confident in their ability. A comprehensive usability test would be needed for further development to clarify this point. The learning activity in the game was satisfactory, however it would need teaching professionals to be involved in the design process throughout the development to ensure the level of activity to be suitable for the target group of children.

7. Discussion

The prototype test found that there is an association between enjoyment and engagement. The children were more likely to be engaged if the game is entertaining, and it was an important first step for children with SEN to gain confidence from the game play. The fact that some of the children started to help each other was one of the most positive outcomes of the prototype test. It suggests that incorporating a collaborative approach in the game may provide further benefit for these children. For example, it could be a multi player game in which some children can be shop owners and others be customers.

7.1. Gender

The gender issues concerning educational multimedia games have been studied (Chambelin 2003; Klawe 1998; Inkpen 1996). It is to be thought that boys and girls have different preferences in games; the boys tend to prefer action, where girls like story telling or creative activities (Klawe 1998). The prototype test of this research could not identify the difference in preferences between the boys and the girls because of the small number of test subjects. From the children's reaction to the character JB, it is possible to design characters which can appeal to both genders, but it may be a challenge to produce a broad appeal in the game play. Providing a choice of different game styles could also be an answer for catering to both genders.

7.2. Speech sound

The children and the evaluators have requested that they would like the characters to speak. Such a response was expected, as the prototype employed an unintelligible abstract sound for the characters. It is relatively easy to assume the benefits of speech, especially to help the children's reading ability.

The main concern with using a speech voice for the characters is what accent to be used. A localised accent can add personalities to characters but there is a danger to project a stereotypical idea. A neutral accent on the other hand can be dull, or can sound authoritative.

One of the 'Grid Club' shopping games (4Learning *et al.* 2001c) has a localised accent, which helps the game environment to look realistic, but there is limitation in the characters responses. For example, a phrase breaks up and loses its flow since some elements such as the amount of money have to be inserted dynamically. Conati and Klawe (2000) have researched the possibilities of the use of socially intelligent agents in educational multimedia games. The architecture is that a character can interact with children in a social and emotional level to support learning by tracking and analysing user actions. The natural and intelligent responses in a characters speech would require a complex computation system, but artificial intelligence technology may make it possible in the near future.

7.3. Further research question

The question for the next step of this study is whether children are able to acquire skills just because they enjoy and keep playing the game. Would the children be able to calculate the correct change when they go to a shop after they have played the 'JB game' over certain period of time? E-GEMS researches (Klawe 1998; Sedighian and Klawe 1996) report that the educational games improved the children's mathematical ability. However Chambelin (2003) argues that positive responses do not always reflect the learning outcome. The research tested the children's knowledge on food safety before and after they spent approximately 40 minutes on games on the website. One participant who seemed to enjoy the game activities did not learn any of the subjects that the website intended to educate. It is because the website content was not interesting for the boy, and Chambelin suggests further research in the relationship between children's personal interest and preferences, and the motivation to learn.

It is not practical to design a game to meet every child's preference, however, it indicates that it is important not to assume all children would learn from playing any game even if they seem to engage with the activity.

8. Conclusion

This research has investigated the key motivational elements in the development of educational multimedia for children with Special Educational Needs.
The study has focused on three key elements in an educational multimedia mathematics game, and what role they play in motivating the children. These key elements are ‘an engaging story’, ‘identifiable characters’, and ‘meaningful feedback’.

The story elements incorporated into the game helped to provide context and meaning to the learning objectives. The children are more able to relate the education to a real world context, and become actively involved in learning. The virtual learning environment disguises the fact that the child is actually being taught subjects which they may previously have a fear of or consider as boring. The main character ’JB’ is a fun figure that the children can relate to; “I need a little help…I’m not very good at counting money”. Characters within the story can help to support the child through the learning experience.
Feedback is an essential element in any learning environment. Multimedia technology can provide immediate feedback for the child, they are able to make mistakes and learn at their own pace. They also support the activities and navigation within the game, and make the environment intuitive for the children. This provided an entertaining experience for the children, which had a positive effect on their attention span, and encouraged them to be actively involved in the game.

The most positive observation is that the children started to help each other. This could indicate that the building of confidence is an important first step to motivate children to be improved learners. It has also highlighted a possibility of creating a collaborative learning environment with multimedia.

The prototype testing analysis strongly suggests that the usability for children, and clear educational goal elements, are equally important motivational factors.

In the development of educational multimedia content, collaborative work between multimedia designers, usability experts and teaching professionals is necessary to produce an effective and entertaining learning tool for children with SEN.

Bibliography

4Learning, Intuitive Media, Oracle Corporation and DfES. (2001a). Grid Club [online], Channel4. Available from:
http://www.gridclub.com
[Accessed 11 January 2003].

4Learning, Intuitive Media, Oracle Corporation and DfES. (2001b). Grid Club: Shop 'Til You Drop [online], Channel4. Available from:
http://www.gridclub.com/have_a_go/maths/puzzlemaths/shop_game.shtml
[Accessed 11 January 2003].

4Learning, Intuitive Media, Oracle Corporation and DfES. (2001c). Grid Club: What if…. you ran a market stall? [online], Channel4. Available from:
http://www.gridclub.com/have_a_go/what_if/market_stall/interactive.shtml
[Accessed 11 January 2003].

Becta. (2003). Primary Schools – ICT and Standards: An analysis of national data from Ofsted and QCA by Becta. Coventry: British Educational Communications and Technology Agency.

Becta. (2001). Computer Games in Education Project [online]. Coventry, British Educational Communications and Technology Agency. Available from:
http://www.becta.org.uk/research/research.cfm?section=1&id=2826
[Accessed 7 June 2003].

Becta and DfES (2002a). ImpaCT2: The Impact of Information and Communication Technologies on Pupil Learning and Attainment: ICT in Schools Research and Evaluation. Series No.7. London: DfES Publications, (DfES/0696/2002).

Becta and DfES. (2002b). ImpaCT2: Pupils' and Teachers' Perceptions of ICT in the Home, School and Community: ICT in Schools Research and Evaluation. Series No.9. London: DfES Publications, (DfES/0742/2002).

Becta and DfES. (2002c). Young People and ICT: Findings from a survey conducted in Autumn 2002: ICT in Schools Research and Evaluation. Series No.12 [online]. London: DfES Publications, (DfES/0789/2002). Available from:
http://www.becta.org.uk/research/research.cfm?section=1&id=547
[Accessed 15 January 2003].

Berger, A., Morris, D. and Portman, J. (2000). Implementing the National Numeracy Strategy: For pupils with learning difficulties: Access to the Daily Mathematics Lesson. London: David Fulton Publishers Ltd.

Chamberlin, B. (2003). Creating Entertaining Games with Educational Content: Case studies for user experiences with the children's website, Food Detectives Fight BAC! ® [online]. Dissertation (PhD). University of Virginia. Available from:
http://www.people.virginia.edu/~bc2j/dissertation/chamberlin_diss.pdf
[Accessed 12 August 2003].

Conati, C. and Klawe, M. (2000). 'Socially Intelligent Agents to Improve the Effectiveness of Educational Games' [online]. Proceedings of AAAI Fall Symposium on Socially Intelligent Agents - The Human in The Loop. Falmouth, MS. 3-5 November 2000. Available from:
http://www.cs.ubc.ca/nest/lci/papers/2000/publications.html
[Accessed 10 September 2003].

DfEE. (1999). The National Numeracy Strategy: Framework for teaching mathematics from Reception to Year 6. Sufforlk: DfEE Publications, (NNFT).

DfES. (2003). Data Collection by Type of Special Educational Need (June 2003), [online]. London: DfES Publications, (LEA/0220/2003). Available from:
http://www.dfes.gov.uk/sen/viewDocument.cfm?dID=709
[Accessed 25 August 2003].

DfES. (2001). Definition of SEN [online]. London, DfES. Available from:
http://www.dfes.gov.uk/sen/viewDocument.cfm?dID=90
[Accessed 25 November 2002].

DfES and National Statistics. (2002). Statistics of Education: Survey of Information and Communications Technology in Schools 2002 [online]. Durham: The Stationery Office, (b07/02). Available from:
http://www.dfes.gov.uk/rsgateway/DB/SBU/b000360/index.shtml
[Accessed 25 November 2002].

Druin, A., Bederson, B., Boltoan, A., Miura, A., Knotts-Callahan, D., and Platt, M. (1999). 'Children as Our technology Design Partners' in Druin, A (ed). The Design of Children's Technology. San Francisco: Morgan Kaufmann Publishers, p51-70.

Dix, A., Finlay, J., Abowd, G. and Beale, R. (1998). Human-Computer Interaction. (2nd ed). Essex: Pearson Education Limited.

Elson-Cook, M. (2001). Principles of Interactive Multimedia. Berkshire: MacGraw-Hill Publishing Company.

Grauberg, E. (1998). Elementary Mathematics and Language Difficulties: A Book for Teachers, Therapists and Parents. London: Whurr Publishers Ltd.

Bell, J. (1999). 'Observation Studies'. in Bell, J. Doing Your Research Project: A guide for first-time researchers in education and social science. Berkshire: MacGraw-Hill Publishing Company, p156-168

Hartras, D. (2000). 'Affective Disorders and Academic Performance in Students with and without Specific Learning Difficulties: Is there a Relationship?' [online]. International Special Education Congress 2000. Manchester. 24-28 July 2000. Available from:
http://www.isec2000.org.uk/abstracts/papers_h/hartas_1.htm
[Accessed 10 August 2003].

Hasselbring,T. and Glaser, C. (2000). 'Use of Computer Technology to Help Students with Special Needs'. The Future of Children: Children and Computer Technology [online], Vol.10, No.2 (Fall/Winter 2000). Available from:
www.futureofchildren.org/usr_doc/vol10no2Art5.pdf
[Accessed 10 August 2003].

Hillage, D. (2000). Count on your computer. Wakefield: SEN Marketing.

Inkpen, K. (1996). Three Important Research Agendas for Educational Multimedia: Learning, Children, and Gender [online]. British Columbia, The University of British Columbia. Available from:
http://www.cs.ubc.ca/labs/imager/tr/inkpen.1996c.html
[Accessed 10 August 2003].

Inkpen, K., Booth, K. and Klawe, M. (1996). Interaction Styles for Educational Computer Environments: A Comparison of Drag-and-Drop vs. Point-and-Click [online]. (Technical Report No. 96-17). Department of Computer Science, British Columbia, The University of British Columbia. Available from:
http://citeseer.nj.nec.com/inkpen91interaction.html
[Accessed 10 August 2003].

Kibel, M. (1992). 'Linking Language to Action', in Miles, T.R and Miles, E (ed), Dyslexia and mathematics. London: Routledge, p42- 57.

Klawe, M. (1998). 'When Does The Use Of Computer Games And Other Interactive Multimedia Software Help Students Learn Mathematics?' [online]. Proceedings of Technology and National Council of Teachers of Mathematics Standards 2000. Arlington, Virginia. 5-6June 1998. Available from:
http://mathforum.org/technology/papers/papers/klawe.html
[Accessed 10 August 2003].

Neptune. (ca. 2002). Percy's Money Box [CD-ROM], London. Available from AVP.

Pidkameny, E. (2002). Levels of Sound [online]. Videogame Music Archive. Available from:
http://www.vgmusic.com/information/vgpaper2.html
[Accessed 8 May 2003].

Preece, J., Rogers, Y. and Sharp, H. (2002). Interaction Design: Beyond Human-Computer Interaction. New York: John Wiley & Sons, Inc.

Prince, B. (1996). 'Tricks and Techniques for Sound Effect Design' [online]. Computer Game Developers Conference, March 1996. Available from: http://www.gamasutra.com/features/sound_and_music/081997/sound_effect.htm
[Accessed 8 May 2003].

Resource. (ca. 2002). Supermarket Plus [CD-ROM], Derby. Available from AVP.

Sedighian, K. and Klawe, M. (1996). 'Super Tangrams: A child-centered approach to designing a computer supported mathematics learning environment' [online] Proceedings of International Conference on the Learning Sciences `96. Evanston/Chicago, IL. 24-27 July 1996. Available from: http://citeseer.nj.nec.com/sedighian96super.html
[Accessed 10 August 2003].

Sedighian, K. (1997). 'Challenge-Driven Learning: A Model for Children's Multimedia Mathematics Learning Environments' [online]. Proceedings of the World Conference on Educational Multimedia and Hypermedia (ED-MEDIA '97). Calgary, Canada, 14-17 June 1997. Available from: http://www.cs.ubc.ca/nest/egems/reports/titles.html
[Accessed 10 August 2003].

Sedighian, K. and Sedighian, A. (1997a). 'Aesthetic Response: Children's Reactions to Color and Graphics in Educational Software' [online]. Proceedings of the World Conference on Educational Multimedia and Hypermedia (ED-MEDIA '97). Calgary, Canada, 14-17 June 1997. Available from: http://www.cs.ubc.ca/nest/egems/reports/titles.html
[Accessed 10 August 2003].

Sedighian, K. and Sedighian, A. (1997b). 'Use of Background Music in Electronic Learning Environments' [online]. Proceedings of the World Conference on Educational Multimedia and Hypermedia (ED-MEDIA '97). Calgary, Canada, 14-17 June 1997. Available from: http://www.cs.ubc.ca/nest/egems/reports/titles.html
[Accessed 3 May 2003].

Spa. (ca. 2002). Let's go shopping [CD-ROM], Tewkesbury. Available from AVP.

TERC. (2002). Zoombinis Maths Journey [CD-ROM], West Sussex. Available from Mindscape.

White Space. (ca. 2002). Numbershark [CD-ROM], London. Available from AVP.

Appendix A-1

Definition of SEN
The Department for Education and Skills describe Special Educational Needs as:

> A child is defined as having special educational needs if he or she has a learning difficulty which needs special teaching. A learning difficulty means that the child has significantly greater difficulty in learning than most children of the same age. Or, it means a child has a disability which needs different educational facilities from those that schools generally provide for children of the same age in the area.
>
> The children who need special educational provision are not only those with obvious learning difficulties, such as those who are physically disabled, deaf or blind. They include those whose learning difficulties are less apparent, such as slow learners and emotionally vulnerable children. It is estimated that up to 20% of school children may need special educational help at some stage in their school careers.
>
> (DfES 2001)

Categories of SEN
The categories of Special Educational Needs for schools and Local Education Authorities given by DfES:

A. Cognition and Learning Needs
- Specific Learning Difficulty (SpLD)
- Moderate Learning Difficulty (MLD)
- Severe Learning Difficulty (SLD)
- Profound and Multiple Learning Difficulty (PMLD)

B. Behaviour, Emotional and Social Development Needs
- Behaviour, Emotional and Social Difficulty (BESD)

C. Communication and Interaction Needs
- Speech, Language and Communication Needs (SLCN)
- Autistic Spectrum Disorder (ASD)

D. Sensory and/or Physical Needs
- Visual Impairment (VI)
- Hearing Impairment (HI)
- Multi-Sensory Impairment (MSI)
- Physical Disability (PD)

(DfES 2003)

Appendix A-2

Description of Moderate Learning Difficulty (MLD)
The target group of children for this study are those who fit into the Moderate Learning Difficulty category, which is described in the DfES guidance reports as:

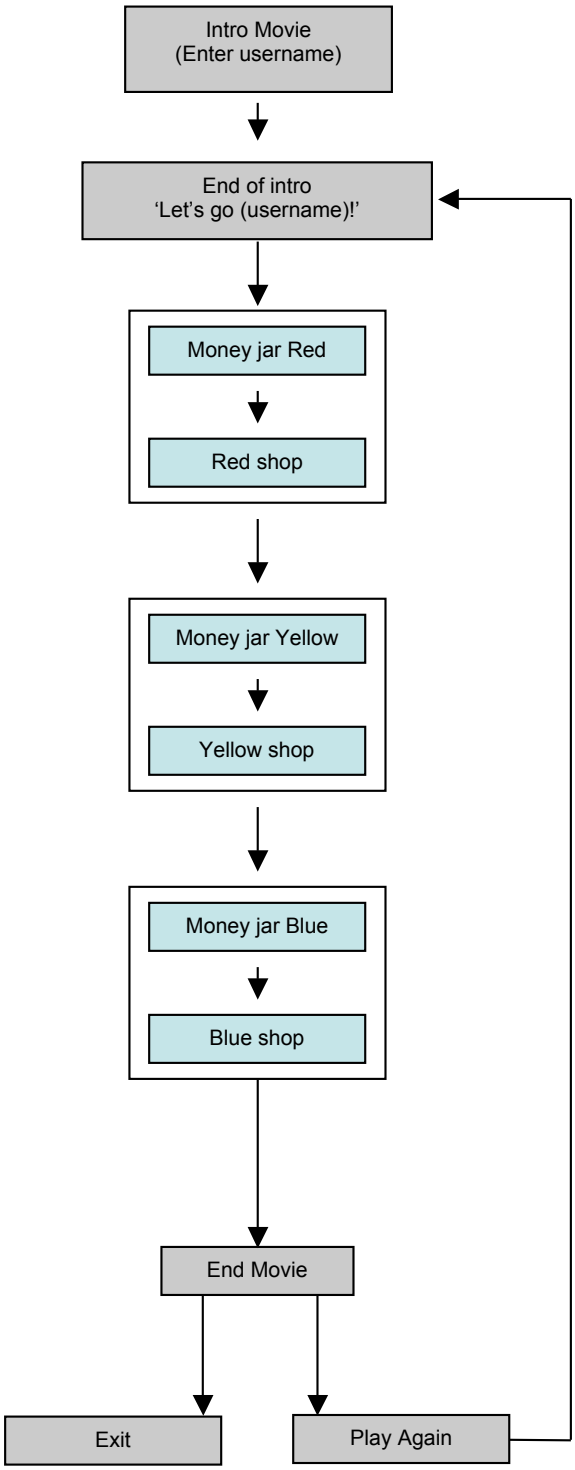
> Pupils with moderate learning difficulties will have attainments significantly below expected levels in most areas of the curriculum, despite appropriate interventions. Their needs will not be able to be met by normal differentiation and the flexibilities of the National Curriculum.
>
> They should only be recorded as MLD if additional educational provision is being made to help them to access the curriculum.
>
> Pupils with moderate learning difficulties have much greater difficulty than their peers in acquiring basic literacy and numeracy skills and in understanding concepts. They may also have associated speech and language delay, low self-esteem, low levels of concentration and under-developed social skills.
>
> (DfES 2003)

Appendix B

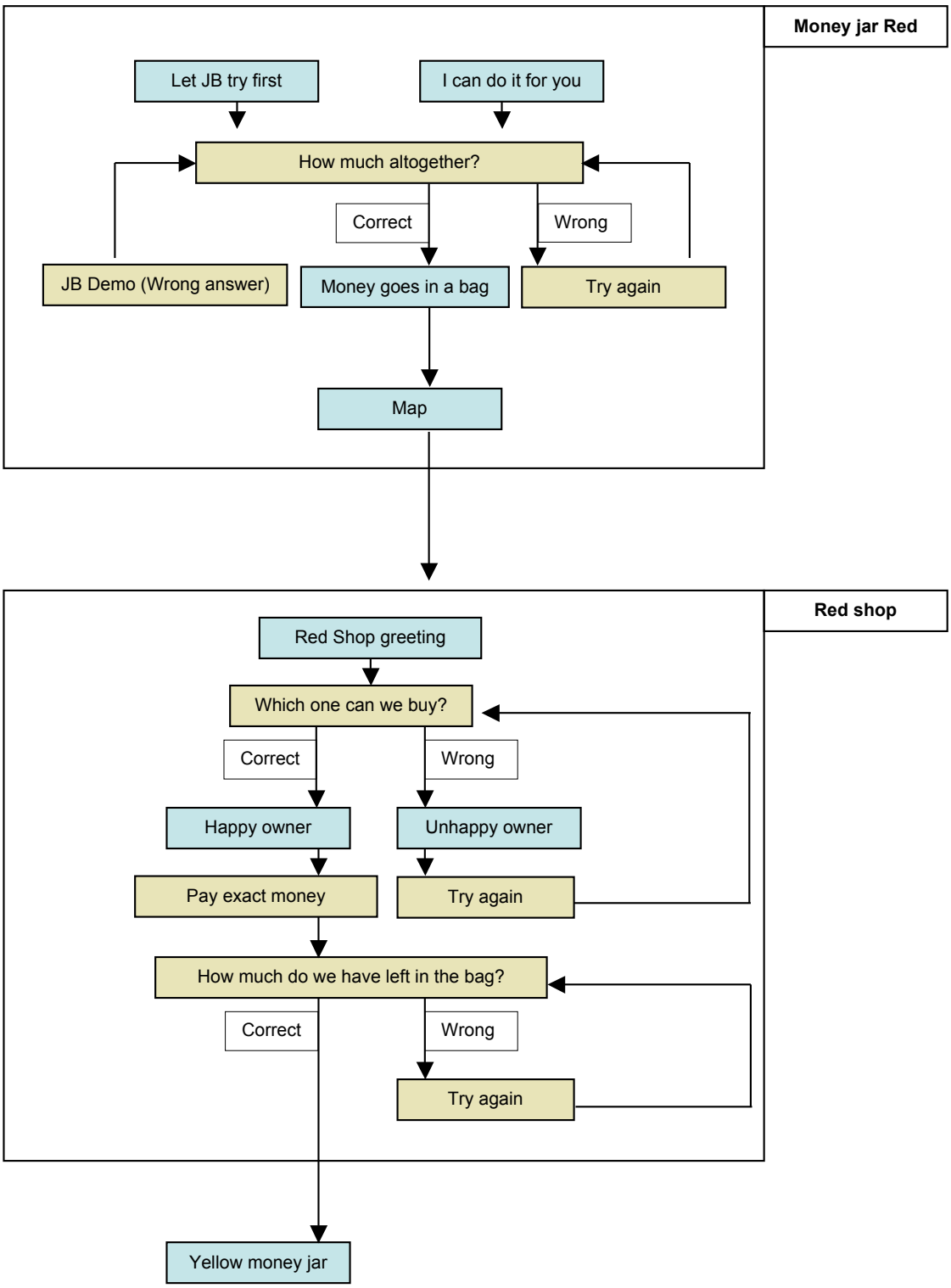
National Numeracy Strategy Excerpt Problem solving skills: Problems involving money for Key Stage 1 (DfEE 1999, p68-69)

Year 1 (4-5 years old)	Year 2 (5-6 years old)	Year 3 (6-7 years old)
Recognise coins and notes of different values		
• Recognise all coins • Exchange coins up to 10p for an equivalent value in smaller coins. Extend to 20p.	• Recognise and appreciate the value of all coins • Exchange coins for their equivalent value using two or three smaller coins.	• Recognise the value of £5, £10 and £20 notes. • Exchange a note for its equivalent value in smaller notes, or £2 or £1 coins or silver coins.
Solve simple word problems involving money and explain how the problem was solved		
• Understand and use in practical contexts: coins, penny, pence, pound, price, cost, costs, costs more, costs less, change, total, pay, how much?	• Understand, use and begin to read: coin, pound, £, pence, price, cost, pay, costs more, costs less, change, total, how much?	• Use, read and begin to write: coin, pound, £, pence, note, price, cost, cheaper, more expensive, less expensive, pay, change, total, value, how much?
• Use own mental strategies to solve problems involving money in contexts such as classroom shop. • Explain methods and reasoning orally and record in own way how the problem was solved. For example: • Find totals and give change: How much altogether is 5p +2p + 1p? • Solve problems: What to buy and how to pay Gita paid 6p for chews with no change. What coins could she use?	• Use mental addition or subtraction, or simple multiplication, and own strategies to solve money problems. • Explain methods and reasoning orally and where appropriate, write a number sentence to show how the problem was solved. For example: • Find totals and give change: I have £14. I am given another£9. How much do I have now? • Solve problems: What to buy and how to pay Investigate ways of using silver coins to pay 50p.	• Use any of the four operations and won strategies to solve money problems. • Explain methods and reasoning orally and, where appropriate, write a number sentence to show how the problem was solved. For example: • Find totals and give change: It costs 75p for a child to swim. How much does it cost for two children? • Solve problems: What to buy and how to pay Which five coins make 74p? What other amounts can you make with five different coins?

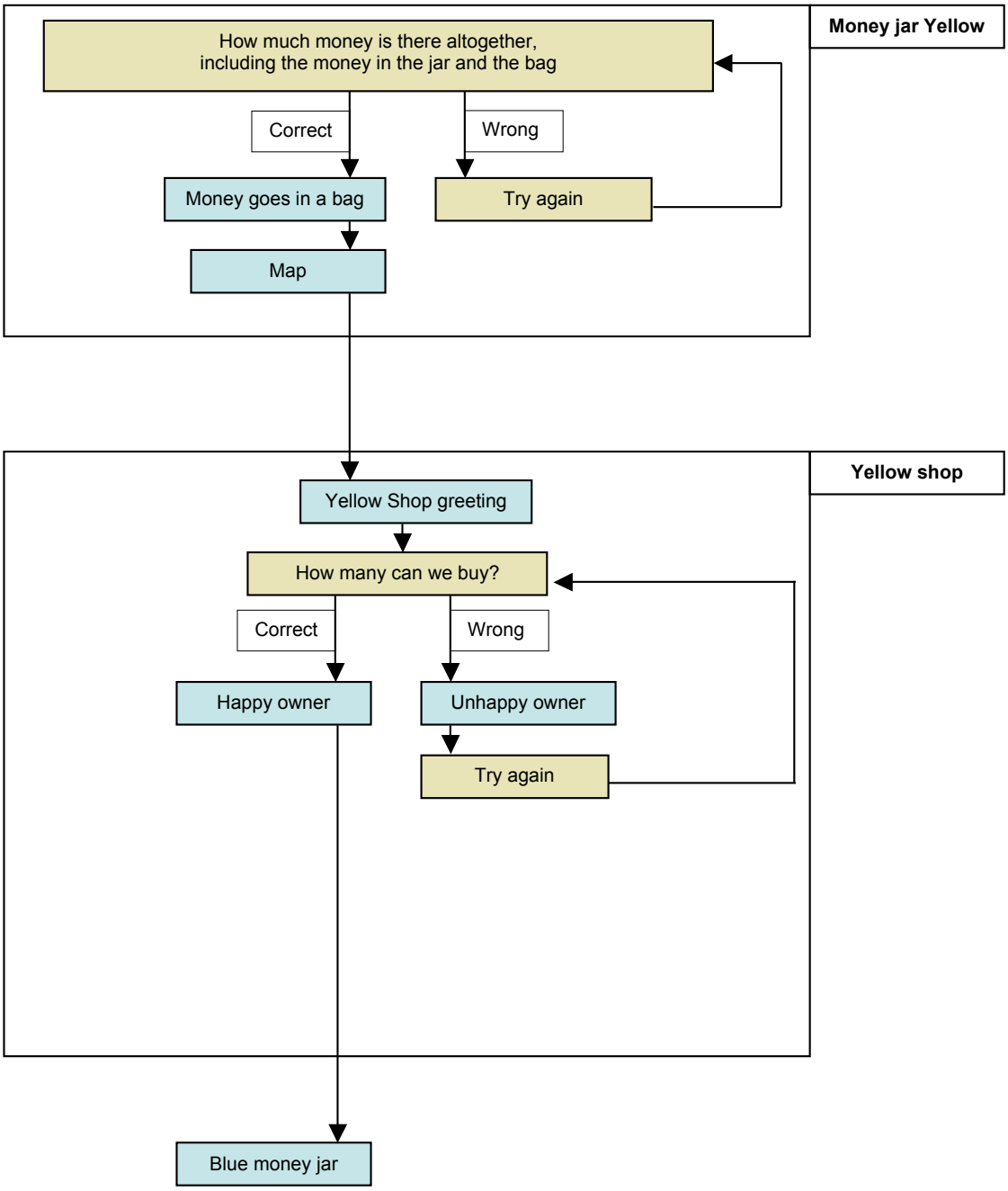
Appendix C-1: Prototype Game Flowchart: The Game Overview



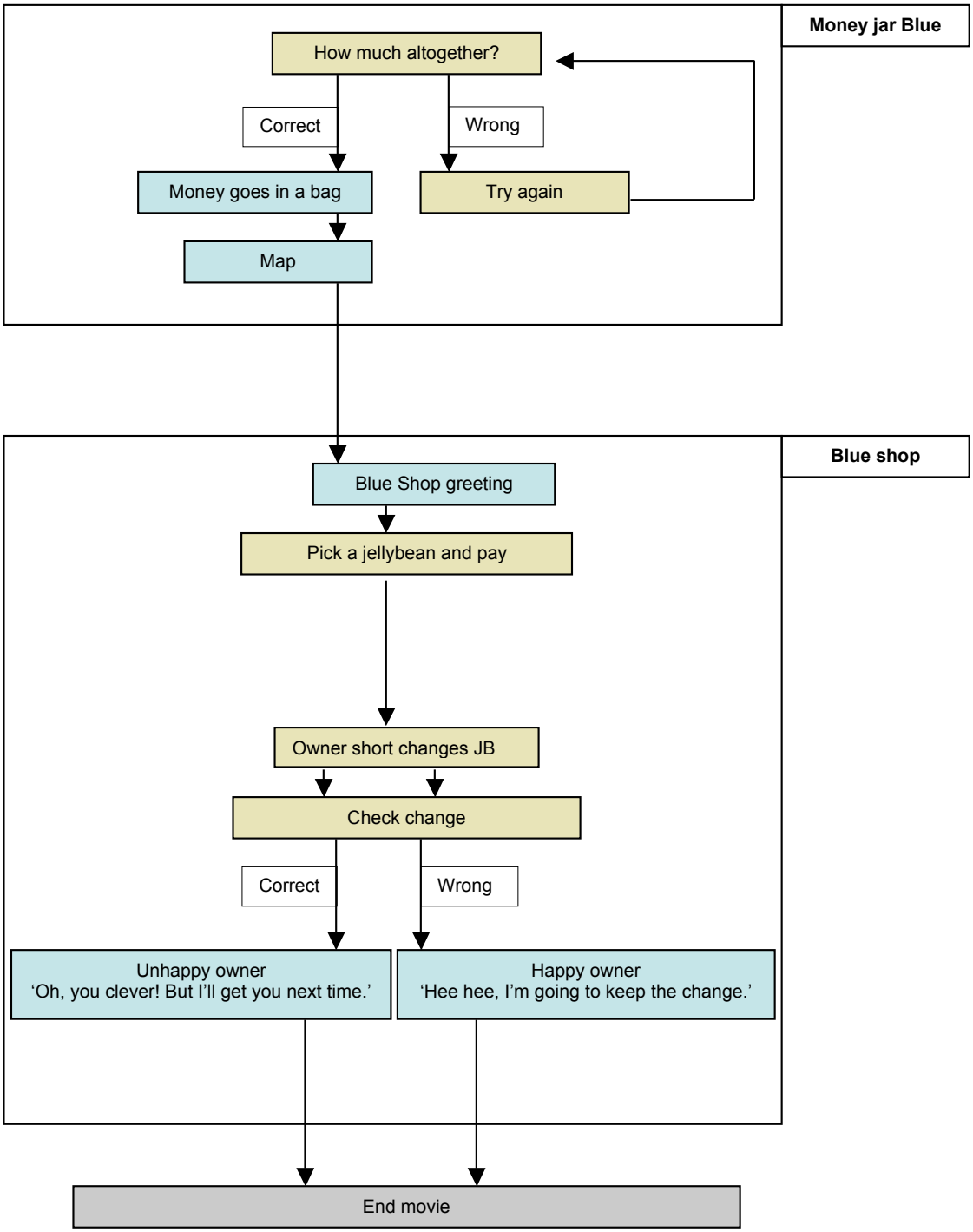
Appendix C-2: Prototype Game Flowchart: The Red Game



Appendix C-3: Prototype Game Flowchart: The Yellow Game



Appendix C-4: Prototype Game Flowchart: The Blue Game



Appendix D

JB Game Questionnaire

Thank you for participating in the testing of the prototype of 'JB Game'. The game is designed for children aged around 10 years who need help with development of their maths skills. The game activities are set to Key Stage 1 in the National Numeracy Strateqy.

Please give general information on the children who participated in the test (if any). All information is confidential, and will only be used for the research of the game.

Name (Male/Female)	**Age**	**Characteristics in general** (ie. General learning ability, attention span etc.)	**Specific understanding and ability in maths**

Please answer the following questions in relation to ‘encouraging’ and ‘engaging’ children.

Characters	Are the characters appropriate for the age group? (too young, too old? Do they relate to the characters?)
Story	Is the story easy to follow? Do you think the story helps children to engage with the game?
Colours	Are the colours used in the game appropriate for the age group? (too young, too old? etc.)
Instructions	Is it easy for children to understand what to do in the game? Do you think children need someone to help?
Navigation	Is it easy for children to find where to click?
Feedback	Do you think the following feedbacks in the game were necessarily to keep children engaged? <u>Sound:</u> <u>Animation:</u> <u>Dialogue:</u>

Text	Is the size of the text easy to read?
Music	Is the background music necessary?
Activities	Are the game activities appropriate for the target group? Any suggestions?

Your name: _____ E-mail address: _____

Name of school: _____

Address of school: _____

Date: _____

Please give your details and send this form back to me by 22nd of September. Thank you.

Yoshiko Yano
SAE Institute (Middlesex University)
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