Evaluation of a Virtual Reality Game for Education

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Abstract

This paper describes and discusses the evaluation of an educational virtual reality game that teaches students multiple domains such as biology, history, spelling and mathematics. The game was built so that it could increase the students' motivation and engagement while they were taught. The evaluation of the educational game consisted of two parts: The first part consisted of a comparison between the Multi-Tutor Game and educational software with a conventional user interface but with the same underlying reasoning mechanisms as the Multi-Tutor Game. The second part aimed at finding out whether the Multi-Tutor Game could replace other computer games, which did not have any educational value in the children's preferences for their entertainment. The results in both parts of the evaluation were quite encouraging.

1. Introduction

One of the desired features of educational software is to be attractive to students so that the time they spend with it and the efficiency of its educational goals are maximized. Children and adolescents are often fascinated by computer games and may spend hours in front of a computer playing. Therefore, instead of being alarmed by this obsession, the educational community may use the fascinating effects of computer games constructively by incorporating them into educational software. Indeed, researchers of educational computing such as Papert (1993) acknowledge the fact that the greatest amount of children's time with the computer is devoted to playing games, which teach them that some forms of learning are fast-paced, immensely compelling and rewarding whereas traditional school strikes many young people as slow and boring. Indeed, some researchers have developed games for educational purposes (e.g. Inkpen et al. 1994; Amory et al. 1998). However, there have not been many educational computer games yet to know if they do indeed promote learning among students.

In view of the above, we have developed a virtual reality game that teaches students several subjects such as mathematics, history, geography and spelling. The game is called Multi-Tutor Game and aims at increasing students' engagement by providing a popular and motivating virtual reality environment. In this way, it aims at being more effective in teaching students than other educational software and traditional media of education. In order to assess the educational effects of the game, we conducted an evaluation among school children who were asked to use the game. The evaluation aimed at showing what the learning effects of the educational computer game were in comparison with educational software which did not involve

any games. Moreover, it aimed at assessing the motivating effects among students to learn while playing. The results of the evaluation were very encouraging in terms of the comparison between the game and the software without a game and in terms of using the game as an assisting tool in the classroom teaching.

2. Description of the educational game

The Multi-Tutor Game consists of four virtual reality games that share the same story and presentation principles, such as music, lights, colors and noise. Moreover they share the same underlying reasoning mechanisms such as the student modeling component. However, each game is designed for a specific application domain and has a different virtual reality world associated with it. The domains are biology, history, spelling and mathematics. Each domain is taught in a different virtual world. History is taught in a virtual world of lands with castles and warriors; biology is taught in a virtual water world; spelling is taught in a virtual world of woods and the domain of mathematics is taught in a virtual world of planets of the outer space.

The Multi-Tutor Game has features that are quite common in virtual reality adventure games. Such features include dungeons, dragons, castles, keys etc. In the Multi-Tutor Game the player tries to reach the “land of knowledge” and find the treasure, which is hidden there. However, to achieve this, the player has to obtain a good score, which is accumulated by all four domains. The idea behind this is to motivate students to have a good standard in lessons, which are different from each other.

In all four worlds there are animated agents that communicate with the players. There are two types of animated agent, the advisor and the guard of a passage. Animated agents, who act as advisors, lead the student to lessons that s/he has to read.

On the other hand, guards of passages ask questions to players in order to let them continue their way into the passage and receive more points for their total score. If a student does not know how to answer a question s/he may ask for help. In such cases, the advisor helps the student give the correct answer and thus the student may continue his/her way into the passage but s/he does not receive any points for the total score.

Many researchers aim to make their multimedia systems more "intelligent" and adaptive to the learner's demands, abilities and knowledge (Hasebrook & Gremm 1999). Adaptivity and intelligence may be added to educational software if a student modeling component is incorporated into it. The student modeling component involves the construction of a qualitative representation that accounts for student behavior in terms of existing background knowledge about the domain and about students learning the domain (Sison & Shimura 1998). The Multi-Tutor Game incorporates a common student modeling component for all four domains involved in the game. For each domain there are certain categories of error that have been encoded into the system. In this way the system may analyze possible erroneous answers of students and perform error diagnosis. Following the diagnosis, the student is given a mark, which is translated to points for his/her total score, depending on the severity of his/her error. For example, if the system diagnoses that the student has only made a typographic error then s/he is given almost full points for his/her answer. However, if s/he gives a totally irrelevant answer then s/he receives almost no points for this answer.

The Multi-Tutor Game holds long-term information about each individual student. Such information is provided by all four domains involved in the Multi-Tutor Game.

In particular, each domain contributes both domain-dependent and domain-independent information about each student. For example, a student may be consistently making a lot of spelling mistakes when s/he is typing answers to questions posed by the game. This is a domain-independent error proneness of the student, which is associated with the degree of the student's carefulness when s/he types answers. This kind of feature is recorded in the student model and is updated constantly in all four domains. Another student feature, which is updated in all four domains concerns the student's spelling skills. If a student makes spelling mistakes in the game worlds of history, biology and mathematics, this affects his/her student model regarding his/her spelling skills and reduces his/her score in the spelling game world. However, naturally there are other domain-dependent errors, which may only be made in the corresponding domain game.

3. Main parts of the evaluation

An evaluation of the Multi-Tutor Game has been conducted so that the educational value of the virtual reality game could be assessed. Evaluation is a crucial part of the design process of educational software, which has to be iterative to a large extent. The educational material must be tried out on students and refined and then tried again and the cycle continued for as long as necessary (Jones et al. 1993).

One important aspect of the evaluation is the reason why educational software is adopted in the first place, i.e. what the underlying rationale is (Jones et al. 1999). In the case of the Multi-Tutor Game, one important reason for the integration of educational software with a virtual reality game was the objective of making educational software more engaging and motivating than other forms of software

while retaining and even improving the underlying reasoning mechanisms. Therefore, one major part of the evaluation consisted of a comparison between the Multi-Tutor Game and educational software with a conventional user interface but with the same underlying reasoning mechanisms as the Multi-Tutor Game. This part of the evaluation was conducted as an experiment, which involved school children and took place in classrooms while human tutors were present but were not actively involved in the evaluation.

Another part of the evaluation aimed at finding out the extent to which the Multi-Tutor Game could be used by children at their leisure time. The underlying rationale of this part of the evaluation was to find out whether the Multi-Tutor Game could replace other computer games, which did not have any educational value in the children's preferences for their entertainment. In this way, the children's game culture could be enriched with educationally beneficial games. This part of the evaluation consisted of an experiment that was conducted in a computer lab where no human teachers were present.

4. Classroom-experiment

School children usually have a preconception of educational means as being totally different from entertainment. In this respect, the first experiment aimed at finding out how school children would react to an educational game in the settings of a real classroom where an entertaining aspect of education would be rather unexpected. Therefore the first experiment took place in a school-classroom.

The experiment involved a class of 16 school children of 11-12 years old and four human teachers that taught history, biology, spelling and mathematics respectively to

this class. The class were divided into two groups of 8 children. The division of children into two groups was based on the human teachers' selection of children in such a way that the two groups had the same distribution of students having good, mediocre and bad grades on average to the four domains involved.

The first group were given the Multi-Tutor Game to work with. The second group were given educational software, which consisted of the underlying reasoning mechanisms of the Multi-Tutor Game but had a simple user interface with no game. Both groups were told that they could use the software for as long as they wished. Moreover, both groups were asked by their human teachers to complete a test using the software. This test was given to them as an informal assignment. In the environment of the Multi-Tutor Game this meant that they had to open all doors in a virtual world and complete their total score. In the environment of the conventional educational software they had to answer a set of questions, which were displayed to them in plain text and context. The rules for the students' receiving their marks through the software were the same for both groups. Finally, both groups were supervised by two computer assistants who helped them with their interaction with the computer.

While children of both groups were using their respective software, their actions and scores were recorded in protocols. After the children of both groups had completed using the programs, the scores they had obtained and the errors they had made which were collected in their user protocols since all their actions, were given to their school teachers. Then the school teachers were asked to repeat the questions where students of both groups had originally given erroneous answers while they used the software. This test would reveal the degree to which students had learnt from their

mistakes while they used the software. The players of the Multi-Tutor Game remembered the correct answers to a slightly higher extent than the other group of students. This showed that the Multi-Tutor Game had achieved its aim of being at least as effective as conventional educational software in the learning outcomes and was in fact slightly better in this respect.

Another aspect that was tested in this experiment was the amount of time that children had spent using the educational software they were given. On average, the students who had used the Multi-Tutor Game had spent more time with the system than the students who had interacted with the conventional educational game. This was partly due to the fact that there was more to explore in the game therefore students needed more time to complete the game. However, it was also partly to the fact that the players of the Multi-Tutor Game had spent more time reading the lessons that were shown to them than the other group of students. This showed that the Multi-Tutor Game was indeed more engaging.

Finally both groups of students were interviewed concerning the software they had used. These interviews revealed that the players of the Multi-Tutor Game were fascinated by the idea of a game in the classroom and they were certainly more enthusiastic about the software that they had used than the other group of students.

5. Lab-experiment

The second experiment took place in a computer lab. The main aim of this experiment was the assessment of the entertaining aspect of the Multi-Tutor Game. The idea behind this was to find out whether the Multi-Tutor Game could be competitive to non-educational computer games in terms of entertainment. If this was

the case then the Multi-Tutor Game would have the advantage of being favored by children in their leisure time. In this way, the educational game could be used both at work time and leisure time and thus would have a greater educational impact on children.

This experiment involved 20 children of 11-12 years old who were all from the same school and class. These children were asked to try this new game and their reactions were observed and analyzed. In addition, the children were interviewed after they had completed their interaction with the game. Unlike the first experiment, there were no human teachers present in this experiment and the game was not associated with school assignments. Therefore the experiment took place in a building away from the children's school. However, in this experiment too there were two computer assistants to help children with the use of the game.

The results from this experiment were quite different from the first one. Since children were not given the game to work with it as an assignment, they considered it merely as a game similar to the commercial games they were familiar with. Therefore their judgment on it focused on the game environment. Most of them (73%) pointed out that the game would be better as a game if it had more virtual objects, more background sounds and more adventure. This was due to the fact that most of them were familiar with commercial virtual reality games therefore they compared the Multi-Tutor Game with them and had higher expectations in this aspect.

Quite a lot of the children (46%) commented on the educational aspect of the game and they said that they found the game quite informative with interesting subjects. Another 35% did not make any comment about the educational content of the game. Finally, 19% of them said that they were annoyed by the fact that the game reminded

them of the school syllabus. However, most of the children (even those who did not like the school syllabus) remembered to a large degree what they had learnt from the game in the domain of the lessons.

6. Conclusions

This paper has described and discussed the evaluation of an educational virtual reality game for multiple domains, the Multi-Tutor Game. The results of the evaluation have shown that school children would be quite happy to work with a computer game, which represents a more amusing teaching fashion than that of conventional educational software. Moreover, the educational benefits of the game are at least as good as those of conventional educational software. However, the experiments also revealed that children are quite familiar with commercial games and therefore they have high expectations from the game environment. Therefore, the virtual reality environment of the Multi-Tutor Game is planned to be enhanced in the near future.

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