On the interaction features of the virtual reality user interface of an educational game

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Abstract: Computer games are so popular among children and adolescents that they are often used to increase the attractiveness of educational software. In this respect, virtual reality game interfaces can serve the purposes of education very well since they are among the most popular interfaces. However, despite their popularity there are still many children and adolescents that do not play games. On the other hand, education is targeted to all students. Thus, if virtual reality game interfaces are to be included in classrooms they have to be designed very carefully so that all students may benefit from them educationally. In this paper, we address the issue of the design of a virtual reality user interface of a game that is meant to teach students geography. 50 students from schools were asked to interact with the game and their actions were recorded. Then the user protocols were analysed. The results of this analysis revealed three important features of the students' interaction with the virtual reality user interface that have to be considered very carefully so that the educational benefits of the game may be maximised.

1. Introduction

Software games are extremely popular among a large portion of adolescents and children. For the majority of children and adolescents the use of computers is related to game –playing at their leisure time (Mumtaz 2001; Kerawalla & Crook 2002). The popularity of games may be exploited for the purposes of education through the creation of educational software games. Indeed, there have already been quite a lot of research projects towards the development of software games for education that aim at increasing the students' motivation and engagement while they learn (e.g. Inkpen et al. 1994; Sedighian 1997; Amory et al. 1998; Conati & Zhou 2002).

However, if these games are to be introduced in classrooms they have to be usable and likeable by all students. Despite the great popularity of software games there are still many children and adolescents who are not familiar with them. For example Griffiths and Hunt (1995) in a study they conducted found that approximately one third of the adolescents play computer games every day whereas the same proportion play once a month or less. This shows among other things, that there is a difference at the level of expertise on software game playing among children and adolescents of the same age. This may also imply that there is a difference in game playing competence among potential users and possibly in the likeability of these games by these potential users. In this case, if computer games are introduced in classrooms and are included in the compulsory assignments and tests that are given to students then these games might cause problems to some students instead of help them in their learning process. For example, Squires and Preece (1996) point out that there should be a synergy between the learning process and a student's interaction with the software.

In this paper, we describe the results of the analysis of students' interactions with an educational virtual reality game. The game is called VR-ENGAGE and is meant to teach children geography through a virtual reality adventure game. VR-ENGAGE has been previously evaluated with respect to its educational effects on students and the results of that evaluation have shown that it has better educational effects on students than an educational

application with a conventional user interface (Virvou et al. 2002). However, the evaluation with respect to the learning outcomes is not sufficient since it does not reveal possible usability problems that students may have had while they interacted with VR-ENGAGE. Moreover, even if a first evaluation of the game has shown that the game is better in terms of the learning outcomes than a non-game educational software, this does not necessarily mean that it could not have been even better if possible usability problems were resolved. Therefore, we have collected user protocols of interactions of students with VR-ENGAGE so that we could analyse them in terms of the virtual reality user interface features. The aim of this analysis was to reveal aspects of the user interface that played an important role in the productivity of students and find out ways that could improve the user interface for the benefit of education.

2. Overview of VR-ENGAGE and its user interface

VR-ENGAGE is a virtual reality game, which is highly interactive. Rokeby (1998) points out that interactivity's promise is that the experience can be something you do rather than something you are given. In this sense, virtual reality interfaces provide an excellent environment for interactivity. The environment of VR-ENGAGE is similar to that of the popular game called "DOOM" (ID-Software 1993), which has many virtual theme worlds with castles and dragons that the player has to navigate through and achieve the goal of reaching the exit. Similarly with DOOM, VR-ENGAGE has also many virtual worlds where the student has to navigate through. There are mediaeval castles in foreign lands, castles under the water, corridors and passages through the fire, temples hiding secrets, dungeons and dragons. The main similarity of VR-ENGAGE with computer games like DOOM lies in their use of a 3D-engine.

The story of VR-ENGAGE incorporates a lot of elements from adventure games. The ultimate goal of a player is to navigate through a virtual world and find the book of wisdom, which is hidden. To achieve the ultimate goal, the player has to be able to go through all the passages of the virtual world that are guarded by dragons and to obtain a score of points, which is higher than a predefined threshold. The total score is the sum of the points that the player has obtained by answering questions. In particular, while the player is navigating through the virtual world, s/he finds closed doors, which are guarded by dragons as illustrated in the example of Figure 1. A guard dragon poses a question to the player from the domain of geography. If players give a correct answer then they receive full points for this question and the dragon allows them to continue their way through the door, which leads them closer to the "book of wisdom".

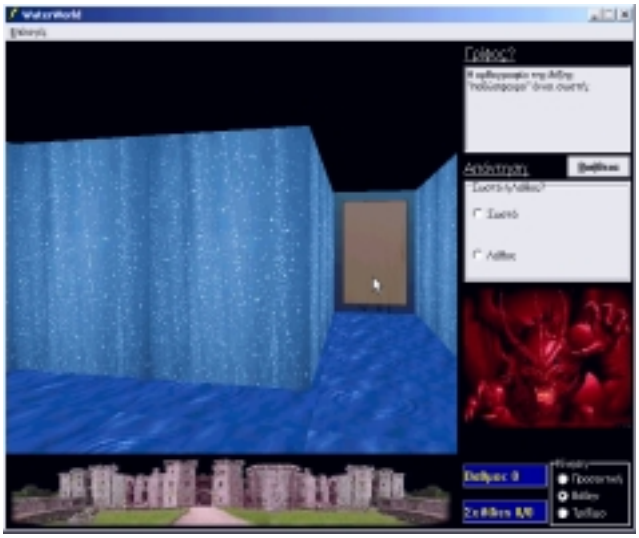

Fig. 1: Virtual water world

As part of the adventure of the game the player may come across certain objects or animated agents. These objects or animated agents appear at random and give hints to students or guide them to tutoring places respectively. In tutoring places, students are encouraged to read a new part of the domain being taught. However, these hints or the parts of the theory read, are not immediately usable by the students since they refer to questions that the students will have to answer at a location of the virtual world other than the one they are currently at. Hence, the students will have to remember these hints or parts of the theory so that they may use them when the time comes. Educationally, these objects or animated agents motivate students to read and memorise important parts of the theory.

Another part of the adventure of the game involves giving players some bonuses in the form of "keys" which may be used to open doors from the virtual world. More specifically, if a student-player has answered 10 questions correctly the player is given a key as a bonus, in which case s/he will not have to answer a question to get through a guarded door. In such cases the bonus-key is kept in the player's inventory list to be used by the player in a difficult situation where s/he does not know how to answer a question posed to him/her by a dragon.

The user interface of VR-ENGAGE involves the navigation of the player through the virtual worlds using the mouse and the keyboard. In case players are lost in the virtual world they may use a map, which is provided on line to show them where they are. The map that every player has access to is an essential part of the game. Every time a student-player uses the map s/he can access a 2D view of the virtual world. The map shows an overview of the structure of the world, the position of the player in it, the doors that have not been opened yet and also the tutor-hints that are available in the world.

3. Analysis of user interactions with VR-ENGAGE

For the purposes of the analysis of user interactions with VR-ENGAGE, we conducted an empirical study which involved students from schools. More specifically, it involved in total 50 school children of 11-12 years old from 5 geography classes. The students that participated were selected from each geography class on the basis of their game playing expertise. For this purpose, all the students of the five classes were interviewed concerning their experience in game-playing and were divided into three groups: experienced, intermediate and novice players. Then, some students from each group were selected at random to participate so that there was sufficient representation of all three categories. Indeed, among the participants there were 15 novices, 20 intermediate and 15 experienced game players. The novice players were given a short training before they were asked to use the game on their own. Then all students were asked to play the game for about 2 hours. During their interaction with the game, they were not allowed to receive any help from their co-students or lab assistants. While they played, all their actions were recorded and collected in protocols that were analysed later.

What was very interesting to find out was that during the game the novice, in game playing, students become much more acquainted with the virtual reality game than the other students, while the experienced users had minimum changes in their game play due to the fact that they were familiar with that kind of environment. Also it was really encouraging to see that only a few students dropped out of the virtual game due to the usability problems they faced while playing.

Three important features of the students' interactions with the game were revealed from the protocols, which could play a very important role for the students' usability problems. They were mainly observed in the novice and intermediate players' protocols. These features were the following:

1. User Interface Acquaintance

While playing a game, a player must become familiar with its user interface. This is very important because the level of understanding of the user interface of a game is an essential part of the story of the game and the user's experience of the adventure. Playing will become easier and more interesting if players are aware of the components, functions and tools that are accessible to them.

The feature of user interface acquaintance showed the player's level of understanding of the user interface of the game. In particular, it revealed whether the player knew the functionality of user interface concepts such as the "Inventory", the "Tutor-hint" etc., and how to read/answer the various questions which were presented in the

relevant section of the screen. For example, supposing a player faced a question that s/he could not answer (s/he tried at least twice) and the player retreated and started wandering around in the virtual world although there was a key inside the player's inventory, then this player was probably ignorant of his/her inventory's usage.

Problems due to the user interface acquaintance were mainly observed in the novice players' protocols and in some protocols of intermediate players. These problems could be addressed in future versions of the game by giving further training to the students on game-playing. Moreover, there could be more automatic help from the game.

2. Navigational Effort

It would be unrealistic to expect all students to know how to play a Virtual Reality game. Indeed, from the protocols collected, it was revealed that not all users knew how to play a 3D Virtual Reality game. The navigation tasks may be easy for students who are very familiar with this kind of game but may be difficult for students who have not had any previous similar experience. Sometimes it is really difficult for new players to get used to a 3D environment movement. The main problem of inexperienced users is related to the navigation in the parts of the virtual scenes.

The navigational effort is a feature that shows how well the user could navigate through the Virtual World. This feature could be measured by the frequency of occurrence of certain actions of the player inside a virtual world. Such actions could be the character's bumping onto a wall (or other virtual items), aimless rotation around the same position, which showed that the player tried to find his/her way out of a point where s/he had been stuck, etc.

The analysis of the protocols collected, revealed that the navigational effort was great for novice players who had wasted quite a lot of their time in pointless situations. However, there were also some navigational problems observed in the experienced players' protocols. These problems can be addressed in a future version of the game by the addition of more maps where the players can see where they are in the virtual world.

3. VR Environment Distractions

The primary goal of the educational virtual reality game was to render learning more attractive for students. Obviously we would not like the student-players to get too distracted by the virtual environment. However, there were some cases that we observed players not paying so much attention to the real purpose of the game, which was to answer all the questions and reach the exit of the labyrinth of the virtual world. Instead of pursuing their main goals, some users used to wander around the virtual world for some time.

There were many cases when the virtual environment drew the player's attention so much that s/he had missed the main point of the educational game (which is learning a specific subject). This was the case in situations when a player found a door, did not answer the riddle, went back to the previous encountered tutor (animated agent), read the hint, went to the door again, did not answer the riddle, went again to the tutor etc. This behaviour showed that from the tutor to the door the player may have been so distracted that s/he forgot the hint.

However, when analysing the protocols, it was generally difficult to say for certain when a student was really in a distraction condition and to measure how much time s/he wasted by being distracted. For example in a case that a player did not know how to answer a question that would allow the opening of a door in the labyrinth and went back to find the Tutor-hint to receive more help, the amount of time that passed until the player went back to give the answer could have been affected by many parameters: The student may have had navigation problems, s/he may have not known how to use the inventory or may have been distracted.

4. Discussion and conclusions

The virtual reality user interface of an educational software game has been analysed based on the interactions of students with it. The students were classified into three categories depending on their expertise in game-playing. These categories were experienced, intermediate and novice game players. The results of the analysis of the students' protocols revealed that the students' actions could be interpreted in terms of three interaction features: user interface acquaintance, navigational effort and VR environment distractions.

The user interface acquaintance showed the extent to which the students knew how to use the user interface of the game. This feature was affected by the narrative of the game but not from the virtual reality environment. In contrast the navigational effort and the VR environment distractions were influenced by the virtual reality environment. The navigational effort was greater for students who used to lose their way in the virtual worlds. On average, for the total of students who participated, this did not happen very frequently. However, when the protocols of each category of student-players were examined separately, it was revealed that novice student-players made quite a lot of navigational effort. This means that on average they had wasted quite a lot of their time trying to find their way in the virtual reality worlds and thus they had been left less time for reading the theory and answering questions that would help them extend and consolidate their knowledge. In such cases, students did not benefit as much as they could from the educational content of the game due to navigation problems in the virtual reality interface. As a consequence, this feature has to be improved by the addition of more maps, which should be more explicit and thus more comprehensible to the novice game players as well.

Finally, the virtual reality distractions were observed in many students' protocols but not to a great extent. The distractions occurred when users behaved as if they had forgotten what their goal was and repeated actions without any particular meaning. The cause underlying this interaction feature cannot be interpreted with certainty. One reason might be because the user is distracted by VR features of the game, such as movements of animated agents, virtual objects, music etc. However, it may also be because the user was absent–minded or had navigational problems. A possible improvement for the problem of VR distraction could be the addition of more user options concerning the number of virtual objects in each scene, the speed of the movement of animated agents, the existence or not of music or the kind of music played in the background. If students are given more options to customise the virtual environment components then they may be less distracted.

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