

Serious Games for use in a Higher Education Environment

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Abstract—This paper presents a serious game that covers the teaching of some basic concepts of computer networks, which has been specifically designed for educating university level students. User requirements are collected through an expert user evaluation with academics as well as with a quantitative evaluation with university students. Based on these results, an online serious game was designed and implemented. The effectiveness of the serious game when applied for teaching purposes is quantified through an end-user evaluation with 30 users. Initial evaluation results show that online serious games can be an effective and useful pedagogic tool in teaching computer networks in a higher education environment.

Keywords—serious games; online games; education and learning.

I. INTRODUCTION

The computer games industry is a young industry, which has seen massive growth over the past two decades. More recently games have broken out of the domain of pure entertainment and are now used in a wide variety of different situations, serious games being one of these. In 2008 alone, the serious games industry was worth US\$1.5 billion, being described by some analysts as the next wave of technology-mediated learning [1], and online serious games are currently among the most successful type of computer game represented on the global market.

There exist different understandings of what the term ‘online gaming’ refers to. One view considers ‘online’ as a mode of interaction, applying the term to multiplayer networked games. The other interpretation of ‘online’ is a repository, which allows games that are embedded in a website to be accessed from anywhere in the world. The use of ‘online’ in this paper assumes the latter interpretation. In terms of the technologies used in online games there is a wide variety ranging from simple 2D representations to much more complex 3D virtual environments, depending on the budget as well as the targeted learning models.

Online virtual communities (i.e. Facebook, mySpace, etc.) are particularly popular among current students, as they enable them to discuss shared interests (communities of interest), to develop social relationships (communities of relationships) and explore new identities (communities of fantasy) [2]. Several of these also provide access to games and serious games, however, not all online virtual communities that propose

serious games are successful in attracting large numbers of users [3]. Although, ways of improving academic-industry collaborations in the field of games have been previously proposed they usually require funding from industry [4]. Classroom teaching with the use of serious games, (i.e. game-based learning), is something higher education would like to engage, however, not many of the institutions not yet made use of this method of teaching [5].

“Serious games can enable learners to undertake tasks and experience situations which would have otherwise been impossible, undesirable for cost, time, logistical and safety reasons” [6]. The success of serious computer games in educational scenarios is based on the combination of audiovisual media that is prevalent in these games, which enhances the absorption of information in the learner's memory [7], [8]. This has been found to considerably improve the process of learning [9]. Different learners will have different preferential learning styles, so a serious game cannot automatically guarantee success, and there is some evidence of the learner's gender playing a role in this [10], however the available evidence generally suggests that the visual medium that serious games employ has a positive effect [11]. Another factor for the success of educational serious games is the actual presentation of the subject matter in the form of computer games, which have been found to improve the players' concentration and attention levels [12]. This not only benefits the retention of information as such, but also increases the learners' motivation, thereby improving the learning experience.

Serious games for education purposes have found acceptance in many areas, including business training and the teaching of primary and secondary school curricula [11], however, at present serious games are underrepresented in higher education settings. In traditional higher education, the student is a passive participant, whereas the active role is taken by the lecturer, which is incompatible with game-based learning that requires the learner to take an active part in playing the educational game [13].

This paper presents an online serious game specifically designed for teaching university students that teaches basic concepts of computer networks. User requirements are collected through an expert user evaluation with university lecturers as well as with a quantitative evaluation with 30 university students. Based on these results, an online serious game was

designed and implemented. The effectiveness of the serious game when applied for teaching purposes is quantified through an end-user evaluation with 30 users.

The rest of this paper is structured as follows. Section II provides relevant background information. Section III presents the expert user evaluation with lecturers whereas section IV illustrates the student requirements. Section V, demonstrates the online serious game in detail and section VI illustrates initial evaluation results. Finally, section VII, presents conclusions, limitations and future work.

II. BACKGROUND

The technology employed in the development of serious games is frequently identical to that used in mainstream entertainment computer games. The main technologies used in serious games have been documented in a recent state-of-the art survey paper [14]. Many of these games do not fall within the online game category, however, over the past few years there has been an explosion of online serious games for a wide range of application areas. One example, although not exactly a serious game, is UA-Chess [15], which is an online multiplayer flash chess game that supports: users who are sighted; those with impaired vision; users who are blind; users with hand-motor impairment; and those with mild memory or cognitive impairment. The game was designed to offer in parallel alternative input and output modalities and interaction methods, reflecting the universal access objective at its core.

Another example is an educational serious game that allows users to interact with 3D Web content (Web3D) using virtual and augmented reality (AR) in engineering education and learning [16]. In this novel approach the lecturer's traditional delivery is enriched by displaying multimedia content locally or over the Internet, as well as in a tabletop AR environment. The prototype implementation of this framework was composed in an XML data repository, an XML-based communications server, and an XML-based client visualisation application.

It should be noted that educational game scenarios do not necessarily have to be directly concerned with the subject matter that the game is supposed to convey, but that they "must be provided in a context in which a story offers useful advice or modelling that helps students to achieve their goals of solving tasks" [17]. The setting is secondary, as long as the educational goals are met and the relevant content is learned by the players. There are a number of different ways in which this can be achieved. Apart from the provision of educational content, some serious games try to improve the student's learning experience through the provision of realistic virtual tutors that they can interact with in a similar manner to a human lecturer. These autonomous intelligent tutoring systems allow students to learn at a pace that they have set themselves by adjusting their virtual teaching strategies to the needs of the students [18]. Virtual tutors in such serious games often resemble the human tutors'

avatars that can be found in virtual multi-user learning environments, employing additional techniques from the domains of conversational user interfaces and interactive digital storytelling [19].

A commonality shared by the serious games that employ these virtual tutors is the aim to mimic a human tutor in order to provide a believable alternative to a human lecturer.

III. LECTURER REQUIREMENTS

The expert user evaluation aimed to discover what lecturers in higher education think of today's teaching methods, the benefits and shortcomings of these and how the lecturers believe students learn best. The study was performed at the department of computer science at Coventry University and three educators from different backgrounds including: elearning, computer graphics and human-computer interaction were interviewed for approximately 30 minutes each.

Initially, it was revealed that they considered today's teaching methods to be generally adequate, mainly because a variety of different methods can be adopted, which benefits the students who each learn in different ways. One lecturer mentioned that he "believes some students prefer auditory and other visual learning". Therefore it is important to understand that not only one method can be used but a number of different methods should be used. The reason for this is that if only one method is used to teach all students then some students may be disadvantaged as this may not be the best method of learning for them. It was suggested that lecturers are not just using one method of teaching but usually try to use a number of methods, also experimenting with new technologies as teaching aids. However, the lecturers who were interviewed stated that with new technology new problems arise such as cost, or time loss whilst setting up the equipment. To effectively use new technologies, a lot more planning and preparation would be required, while at the same time this also would be unlikely to provide a lot of flexibility. They also believed that "technology can be good, but if forced not accepted". As a result, it is important to understand whether the students feel the new technology or teaching method is effective for them.

All the lecturers considered that the main benefits of current teaching methods are that they provide simplicity, structured learning and flexibility. Some of the problems with presently employed teaching methods are that they are more focused on lectures and seminars, which do not necessarily involve the students, so one of the major problems with today's teaching methods is that it can be difficult to know what the students are going away with and what they have understood. An additional point made during the interviews was that a problem with current teaching methods is that students may not 'listen', 'respond' or 'be interested'. In this respect, learning via computer games may help to eliminate a large number of these problems due to students being able to become part of the learning process and taking an

active, rather than a passive role in interactions. The result is that the students become more interested in what they are doing and enjoy the learning process, which in turn will result in them taking newly obtained knowledge away with them [20].

When the lecturers were asked whether they believe today's teaching methods to be effective with students, their overall response was positive, however, one stated that the most effective methods are those which involve the students and require them to perform a task. This reflects the comments made about the problems with today's teaching methods and improvements which the lecturers believe could be made. The lecturers believe that the improvements which can be made to current teaching methods are to include more problem-based learning scenarios, which involve the students and also require them to take part in activities that encourage them to work with others and solve problems.

All of the three lecturers were of the opinion that students learn best when this approach to learning and teaching is used because they are involved in the task which engages them with the subject material, enabling them to do something themselves and to solve problems. They also thought that there were other improvements which could be made, such as tying in practical work with assessment. Actively involving students in the learning process can be achieved through the use of computer games, as these allow students to work individually as well as in a group. This not only enables students to work with something that appears relevant to them, but is also a very strong visual learning tool, which corresponds with one way in which humans learn quickly and memorize a lot more information than without visual aids. Using computer games in education process immerses students in the learning process, providing a 'fun' learning experience.

When the lecturers were asked how they believed the students to prefer to work, the overall response was that they perceived students to prefer to work individually for assessed work and that it were mainly students who are weaker or would like the work load to be shared who prefer to work in groups. On the other hand, however, students like to work in groups for unassessed work. All the lecturers felt that because students prefer to work individually they had to organise group work sessions. They also believed that current teaching methods do not enable immersion or encourage collaboration which they considered being an important element of learning and that was why they were trying to incorporate more problem based learning. Problem-based learning can be achieved through the application of computer games as these can be used to create many different scenarios that suit different needs. All of the lecturers said they thought computer games can be used for teaching and learning but that they would have to be used in areas where they were needed and not randomly. One lecturer mentioned that "random use can make things harder not simpler".

The lecturers who took part in the interviews teach in different subject areas and are currently using

educational approaches, which they feel suit them. However all of them would be willing to use games in their modules if these were available for them, but all felt that they would need to see first how much this could benefit them to make up their minds. This indicates that some uncertainty exists in the lecturers acceptance of games, however, once it could be demonstrated to them how games could help to teach in the areas they specialize in, this would likely help to change their minds to a certain 'yes'. Overall, all of the lectures believed that presently employed teaching methods were good as new technologies and approaches were being used. They also believed that one could not completely eliminate the traditional methods of teaching but that one could incorporate new technologies, such as serious computer games. Finally, the point was raised that it would have to be ensured that the technology works properly and that it would benefit students to use games.

IV. STUDENT REQUIREMENTS

The evaluation was conducted with undergraduate students at Coventry University. The sample population of 30 students who took part in the testing was equally gender-balanced, consisting of 15 male and 15 female students. The average time for each assessment was 45 minutes and students had to complete questionnaires (rating the questions between 1 = not very good and 5 = excellent) with specific questions regarding their learning preferences in higher education.

Given that many different approaches to teaching exist, it is important to understand which method the students consider to be most suitable for them and which method of learning suits them best. Students were first asked how they learn best and then presented with the following options- going to lectures, reading from books/papers, research on the internet, taking exams or participated learning. Overall the students answered that they learned best when they could go to lectures, read and research information but also participate in the learning process (Figure 2). This indicates that students like to work in many different ways and do not restrict themselves to a single method. It should be noted, however, that attending lectures and participated learning was more popular among the female students than the male students. These mainly preferred to read from books or papers and to be able to do research on the internet.

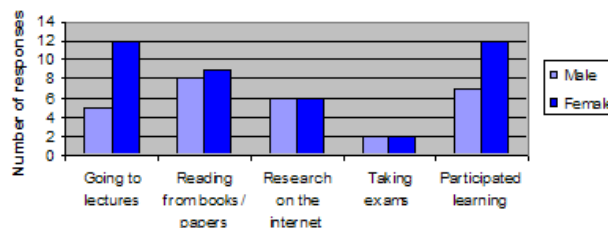


Figure 1 How students learn best [21]

Students were also asked why they believe they learned best from the particular methods that they had

selected in the questionnaires. Student responses regarding participated learning were that this method enables them to work together with others, meaning that more views and opinions can be discussed, allowing ideas to be shared. Students also felt more involved and interested in the task, resulting in them learning more and taking away a lot more information. Two out of the thirty participants had disabilities; one had hearing difficulty and the other one suffered from dyslexia. These students found participated learning a lot more beneficial for them as they were able to be involved and see what they are doing, whereas with other methods of learning they felt they were not achieving as much. Going to lectures was more popular with students who preferred structured learning. Students also liked being able to read from books, papers and doing research on the internet; they believe it enables them to work in their own time at their own pace. However the overall results show that students prefer learning from more than one method, this is because it enables learning from a variety of sources. Students said they like to have structured learning which is achieved from attending lectures but also like to be able to research upon what they have been taught in the lecture in more detail by reading from books, papers and doing research on the internet.

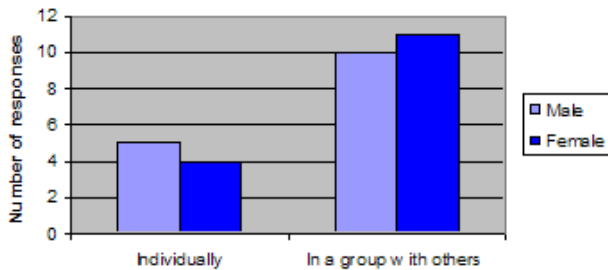


Figure 2 How students prefer to work [21]

Moreover, to discover how students prefer to work they were asked whether they prefer to work individually or in a group with other (Figure 3). Twenty one students prefer to work in groups rather than individually, however working in groups is slightly more popular with females than males. This reflects the results from how students learn best as more females than males preferred participated learning which requires working with others. Fewer students prefer to work individually, however slightly more males prefer to work individually than females, this also reflects the results of how students learn best as more males preferred learning by reading books, papers and also being able to research on the internet which is mostly done individually rather than in groups. Working in a group with others was more popular on a whole. Therefore showing almost 75% of the end users prefer working in a group with other over working individually.

V. CHEOPS GAME

Game-based learning has the potential to significantly improve training activities and initiatives [22], and although serious games are seldomly employed

in higher education, they provide a viable alternative to traditional pedagogic approaches. To illustrate the effectiveness of learning using online games, a flash based game called Cheops was developed [23]. Macromedia Flash was selected as the development platform since it allows for fast and effective production of interactive applications. It also allows for the resulting applications to be deployed online and then accessed by any computing device capable of interpreting its file format. The main goal of the game is to help students understand some of the basic concepts of modern computer networks (see next sub-sections). A high level overview of the mode of operation of the game is presented in Figure 3.

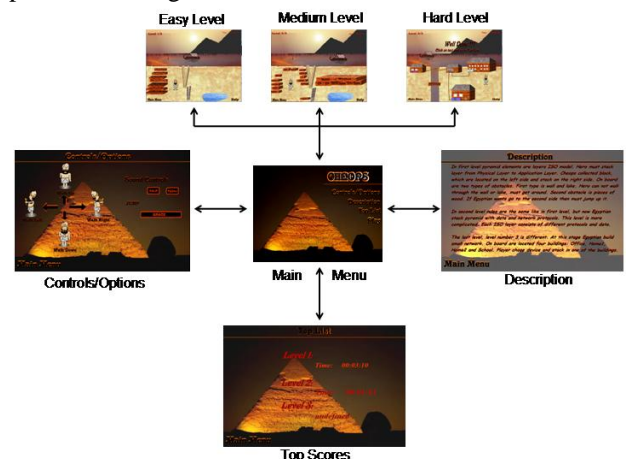


Figure 3 Method of operation of the game [23]

The game itself is set in ancient Egypt. The game's protagonist is an ancient Egyptian named "Cheops" who has the task to build pyramids. The network elements that the users are supposed to learn about are integrated into the game scenario. When the user starts the game a brief menu is presented. This includes a 'Start' button in case if the user wants to skip the introduction and go straight to the game's main board [23]. After pressing the 'Play' button, the user is presented with the main board and starts the first level of the game. The board displays the elapsed time and the current level. In this prototype, three different game levels have been specified that correspond to three difficulty settings: *easy*; *medium*; and *hard*.

A. Easy Level

This level concerns building the pyramid which is made up using the layers of the International Organization for Standardization (ISO) networking model [24]. The ISO Reference Model was created for the Open System Interconnection Reference Model (OSI Reference Model or OSI Model) and consists of seven layers to describe networked systems. In this level, players must stack layers from the 'Physical Layer' to the 'Application Layer'. In particular, they must pick up the different layer blocks which are located on the left hand side of the game screen (Figure 4) and then place

them in the correct order on the right hand side of the game screen.

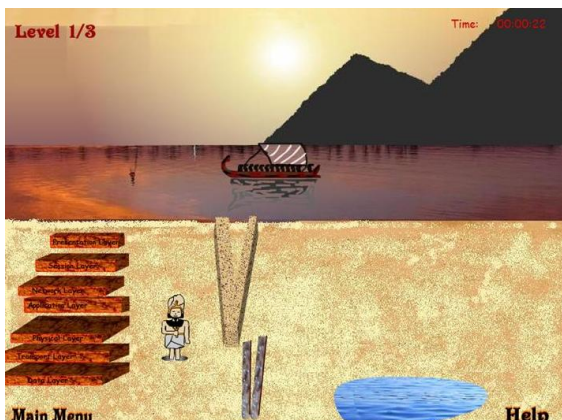


Figure 4 Easy Level [23]

The first level presents players with two different categories of obstacles. The first category includes a wall (located in the middle of the game, see Figure 4) and a lake. Players can not walk through the wall or the lake, but must go around it. The second category of obstacles is the wood lying on the ground. To get across the wood, players have to jump over it. Players can pick up only one block at any one time. If the wrong layer is placed, the screen immediately displays an announcement: “Wrong Layer” with accompanying sound error. On the other hand, when all blocks are correctly put together, the game displays an announcement saying: “Well done!!! Click on text and go to next level”.

B. Medium Level

In the second level the rules remain the same as in the preceding level, however, the aim is to stack the pyramid with blocks representing data and network protocols. This level is more complex compared to the previous one (Level 1). Each ISO model layer consists of different protocols and data. For example the ‘Transport Layer’ consists of the Transmission Control Protocol (TCP) [25] and the User Datagram Protocol (UDP) [26]. An exemplar of this level is presented in Figure 5.

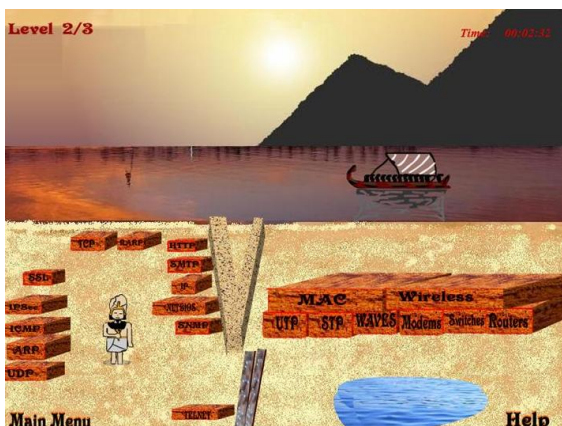


Figure 5 Medium Level [23]

TCP is one of the core protocols of the Internet Protocol Suite and one of the two original components of the suite, so the entire suite is commonly referred to as TCP/IP [25]. Similarly to TCP, UDP is one of the core members of the Internet Protocol Suite, and allows computer applications to send messages to other hosts on an Internet Protocol (IP) network without requiring prior communications to set up special transmission channels or data paths [26]. In the same way to the previous level, messages appear indicating when the solution is found.

C. Hard Level

The final level is very different compared to the previous ones. At this stage, players must build a small computer network. A computer network allows multiple computers to communicate with other computers and to share resources and information. Four buildings are now located on the board including: *Office*, *Home1*, *Home2* and *School*. When the user stands on a building, then a label for the particular building and the number of required hosts is displayed. Office (1 host) and School (14 host) are located very close to one another. Home1 (6 hosts) is located a bit farther away. One building, i.e. Home2 (1 host) is separated from the rest by the river. The player can get through the river only when he chooses the correct device. The left side includes the available devices like: Router, Switch 16 ports, Switch 8 ports, and cables: STP and UTP.



Figure 6 Hard Level [23]

There is also one wireless device for creating a Wireless Local Area Network (WLAN). The player has to select devices and place them in one of the buildings, then choose the cable and connect them. If the network is built in the proper way a message is displayed on the screen: “Well done!!! Click on text and go to Top List”.

VI. INITIAL EVALUATION

The main aim of this research was to test the game’s usefulness, assess game design and to verify the educational aspects of the game. A quantitative study with 30 users was done using semi-structured questionnaires. Participants consisted of students from Coventry University as well as employees from a small

IT company [23]. The game was deployed on a web-site so that it could be accessible from personal computers as well as mobile devices (personal digital assistants and smartphones).

A. General Purpose Questions

The first question aimed at obtaining a general view about the popularity of the visualisation medium (static or dynamic). Around 83% of responders preferred static devices (i.e. personal computer, laptop, console, etc) and only 17% chose mobile devices (i.e. cellphones, personal digital assistants, etc) as the preferred game tool. Next users were asked if they were familiar with Flash-based games. Only 23% of responders responded positive. All of the participants were familiar with computer and console games with 58% preferring to play online games.

B. Entertainment

In terms of entertainment value, users reported that they considered the ‘Hard Level’ to be the most entertaining out of all 3 levels. In particular, 90% of responders selected the ‘Hard Level’ as being the most entertaining, whereas only 10% of users chose the ‘Easy Level’. It is worth-mentioning that nobody selected the ‘Medium Level’ as illustrated in Figure 7.

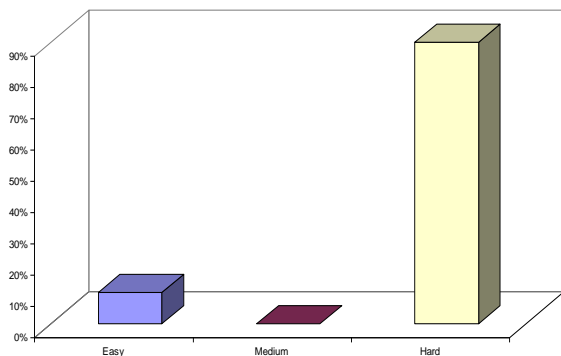


Figure 7 Comparison of the entertainment between the levels

This clearly indicates that users preferred the most challenging and difficult task because it was ‘fun’ to play. Fun elements in the easy and medium levels were visibly reduced compared to the ‘Hard Level’.

C. Difficulty

As far as the most difficult level is concerned, responders reported that the ‘Medium Level’ was the most difficult to play. Only 7% of the users selected the ‘Hard Level’, compared to 93% who named the ‘Medium Level’, while nobody chose the ‘Easy Level’ as shown in Figure 8.

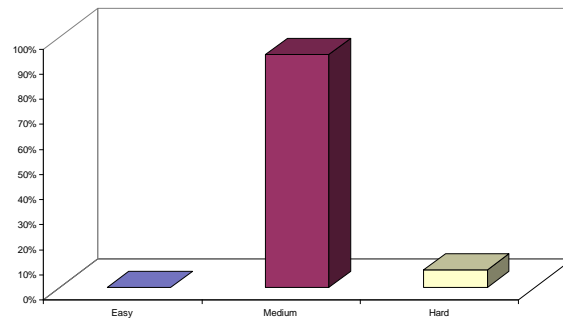


Figure 8 Comparison of the difficulties between the levels

The results for this question were meeting expectation, as each level was harder than the preceding one. However, it was not expected that there would be that much of a difference between the perception of difficulty for the levels.

D. Knowledge

The next question aimed at measuring the knowledge gained by playing the game. Participants were aware that the game was designed for learning purposes, but the purpose of this question was to measure the difference of the three levels. Recorded feedback is presented in Figure 9.

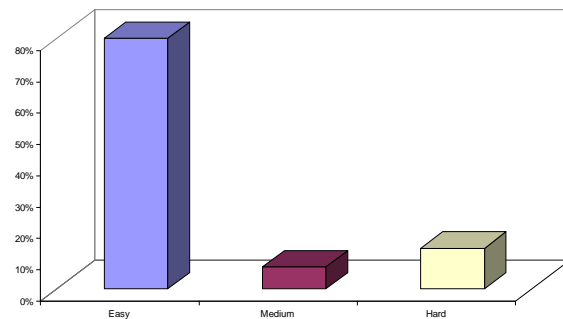


Figure 9 Comparison of the knowledge gained between the levels

Results showed that 80% of responders thought that the ‘Easy Level’ provided the best knowledge. On the other hand, the ‘Medium Level’ scored only 7%, and the ‘Hard Level’ 13%. This illustrates that although the ‘Easy Level’ may not be as entertaining as the other levels, and neither as difficult, it allows players to absorb and retain knowledge much better.

E. Overall Experience

During the final part of the end-user evaluation the overall player experience was measured. In particular, comparative questions were asked aimed towards assessing in detail: *individual game components*; *individual design components*; *complexity versus knowledge*; and *entertainment versus graphics versus knowledge*. The first stage of the questionnaire was dedicated to assess the game’s usefulness. The main subjects of assessment were: *introduction menu*; *help menu*; *description*; *controls/options* and *usability of top*

list. Figure 10 presents the detailed assessment of the usefulness of the individual game interface components.

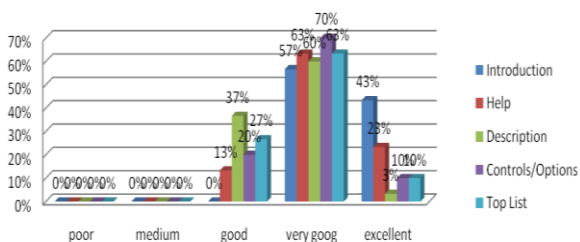


Figure 10 Detailed assessment of game components [23]

The average assessment of all elements was calculated to score around 74.7%. The ‘introduction menu’ was rated around 85.8%, the ‘help menu’ as 77.5%, the ‘description’ as 66.7%, the ‘controls/options’ as 72.5% and the ‘top list’ as 70.8%. In the next stage of the evaluation, game design elements were assessed. The main subjects of the assessment included the: *overall readability*; *sound* and *background*. Figure 11 illustrates a comparative analysis between these elements.

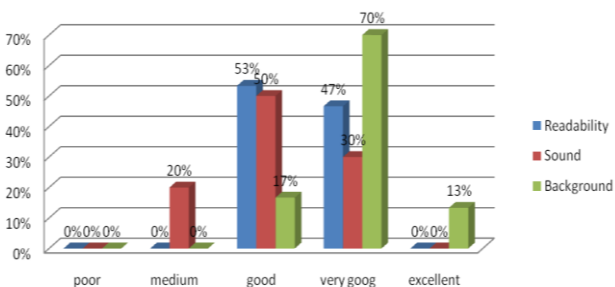


Figure 11 Design components [23]

The average assessment of all elements of the game’s design is approximately 62.8%. The ‘readability’ scored around 61.7%, the ‘sound’ around 52.5% and ‘background’ around 74.2%. Furthermore, a more in-depth analysis between the complexity of the different levels and the knowledge gained is presented in Figure 12.

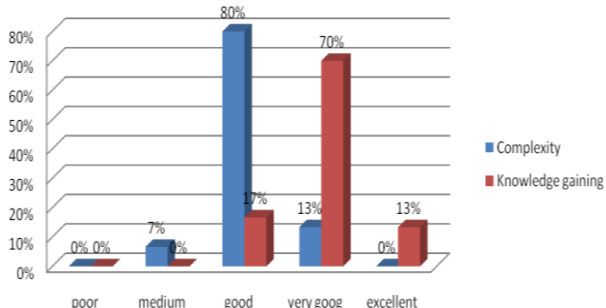


Figure 12 Complexity vs Knowledge [23]

From these results it is obvious that knowledge gained is more important than complexity. Participants valued complexity as ‘good’ but they preferred to gain knowledge first (valued as ‘very good’) and then move towards more complex theoretical issues and concepts. The final part of the evaluation was dedicated to assessing the player’s expectations. This stage provides

insight into the players’ perception of the game’s level of achievement in meeting player expectations. The main subjects of assessment were the following: *entertainment*; *graphics* and *knowledge gained* [23]. Figure 13 presents the selections of all players regarding their expectations.

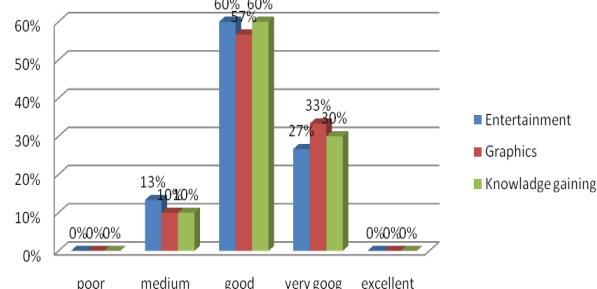


Figure 13 Entertainment vs Graphics vs Knowledge [23]

It is worth-mentioning that participants reported as being ‘very good’ the game’s visualisation first, which scored highest (33% participants), then knowledge gained (30% of participants) and finally entertainment (27% of participants). On the other hand, for ‘good’, participants gave an equal score to both entertainment and knowledge gained (60% of participants) whereas visualisation scored a bit less (57% of participants). Results from this part of the questionnaire are important for the future development of serious games for this subject matter and target audience.

VII. CONCLUSIONS AND FUTURE WORK

The online educational game has been developed successfully and it fulfils the specified requirements. The performed evaluation shows that online serious games can be effective and useful elements of higher education. An initial evaluation with 30 users reported 23% of responders knew what a Flash game is. That number suggests that the technique of game creation is not important for the players. On the other hand, the entertainment value and the game’s complexity are important. Knowledge about networking was also found to be very low – fourteen out of thirty responders assessed their own network knowledge as ‘poor’. Moreover, the responders assessed the usefulness of this game to be around 74.7%. The disadvantage of this game was a too difficult level 2 and a too easy level 3. Generally, this project achieved 54.7% of the player’s expectations.

One of the main limitations of this work is that of ‘believability’ of the game, especially with the ‘harder’ level. Often, when believability breaks players are reminded that they are playing a game and the illusion is lost. This usually results in disengagement and loss of benefit of using this particular medium. To address this issue, more levels will be included in the future to provide a smoother transition between the different levels as well as to provide educational materials pertaining to more theoretical issues of networking. In

addition, more scenarios will be designed for more subject areas of computing such as: computer graphics, multimedia and creative computing. Finally, a 3D immersive environment will be designed to evaluate the differences between 2D interactive environments and more immersive 3D environments.

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