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Application of serious games in education: prerequisites, motivating factors and state of the art

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Abstract. In this paper a review was performed on the application of serious games in education. The main prerequisites, pros and cons have been analysed and the key motivating factors which make people play games were identified. Additionally a review of the existing serious games used for educational purpose were performed. The results of the study showed that even though there are many serious games, very few are used as a mandatory tool in education. In some universities serious games are used in economics classes, however there are no known applications in engineering specialities.

Key words: game based learning, serious games, education.

1. Introduction

In the past years, a lot of efforts were put in the development of game-based learning and the so called serious games. They use a combination of digital technologies and games, which aim to improve the understanding of a certain problem. The main prerequisites for the development of this technology are the ability of computer games to motivate, attract and maintain the attention of the user by giving exact goals and assignments [1].

De Schutter and Vanden suggested that games are applicable in education because they provide a safe environment for simulation of the reality, thus allowing to use the method of trial and error. Other reasons include the possibility to tune up the difficulty, which allows to maintain the motivation, as well as the fact that games could be the theme of social communications, which also enhances the motivation of the players [2].

According to Stewart, the use of 3D graphics and realistic models of the real world is a powerful tool for impact on the players, allowing them to investigate, visualize, repeat and experiment without the risk of real consequences [3].

The goal of this paper is to analyse the reasons which motivate people to play games, to systematize the main principles for designing of serious games, and to review the serious games available on the market and their spheres of application.

2. Classifications and motivating factors

2.1. *Classification of games*

The purpose of the serious games is to train in a virtual environment, which stimulates and motivates the learning by providing preliminary goals [4]. The digital game is a software, which visualizes the information for one or more players, responds to their commands, follows a number of rules (rules of the game), and most often they provide an environment for solving of problems [5]. The games usually include a number of major parts. The first one is the introduction to the goals, the tasks and the rules of the game. Then follows the game itself, i.e. the execution of the tasks, where the problem or challenge is created. Often this phase includes a feedback to inform the player of the current progress. In the last phase of a game the player can review his results [5].

In terms of genre, computer games can be classified by many characteristics, depending on their goal, style, etc. Every game could fall into one or more categories including but not limited to adventure, board game, logical game, action game, roleplaying game, strategy, simulator, sports game, fighting game, educational game, puzzle and so on [6,7]. Serious games can include parts of one or more genres, and depending on the way they were designed can fall into three categories [8]:

- Education and recreation – the design of these games is based on an educational content and the game logic is added later. Their main disadvantage is that the recreation aspect of the game is not accounted for during

the design phase, which leads to reduced motivation of the player;

- Redesign of an existing game – existing commercial games are improved with educational purpose. The disadvantage of this approach is that their initial design was not meant for education;
- Intermediate category – the balance between recreation and education is created at design time.

2.2. Motivating factors

Numerous studies have been carried out about the reasons which make people play [6, 9, 10, 11]. The results return various reasons but the most common are for pleasure, for entertainment and for challenge. According to Azli, other reasons which make people play computer games are curiosity and communication [6]. Good states a number of additional reasons like the desire to accomplish a goal, the opportunity to make a choice and to take part in a certain action, a sense for cooperation, etc. [7].

According to Stewart, another motivating reasons could be the sense for control of the situation, the feedback, the challenge and competition, the autonomy, the realism or phantasy, etc. [3].

2.3. *Pros and cons of game based learning*

Although there are some similarities between traditional and game based learning, there are also a number of differences. Serious games rely on the method "trial and failure" with minimal instructions and a great freedom for manipulation of the beginning and ending conditions, while the role of the tutor is mainly as a coordinator [12].

The main advantage of learning through serious games is the commitment which the game creates, which leads to increased cognitive links with real life situations, and to the creation of certain associations (for example visual, auditory, etc.) [13]. Mitchell and Savill-Smith analysed the pros and cons from the use of computer games for education [14]. They stated that the main advantages are the increase of some cognitive skills like attention and memory. In another study Hubert-Wallander et al. showed that a couple hours of game based education could increase the focus, the ability to effectively perform different tasks, to search and find the required goal [15]. Stewart et al. acknowledged that learning through serious games is a challenge for older people, but it also allows to simultaneously learn the content of the game as well as the usage of new technologies [3].

Corti stated that with an interesting storyline, some drama, humour and non-playable characters, games could create an immersive experience, which allows to remember not only what happened, but why it happened. The knowledge and skills acquired in such ways could be directly applied on the workplace [16].

The main disadvantages of game based learning could be divided in two main categories: health problems and psychological problems [1].

2.4. *Assessment and indicators for success*

In order to assess the success from game based learning, specific indicators should be used. In order to define them the learning goals should be defined as well as the method for estimation both qualitatively and quantitatively. Some of these indicators should be able to assess the commitment, the motivation and the acquired new skills and knowledge, even if the main objective of the game was not reached. Ypsilanti et al. (2014) gives an example with the games which support different levels of difficulty and different scenarios, where the indicator for success has to be adapted for the different situations [1].

One of the criteria for successful application of education through games is the so called "transfer of the problem", which shows the ability of the student to transfer the learned from the virtual into a real environment [17, 18]. Csikszentmihalyi (1999) introduced the term "theory of the flow" (fig. 1), according to which in order to maintain the motivation and focus of the students, the difficulty level should correspond to their skills [19]. In other words the game should provide challenges which are neither too easy, nor too difficult for each individual player.

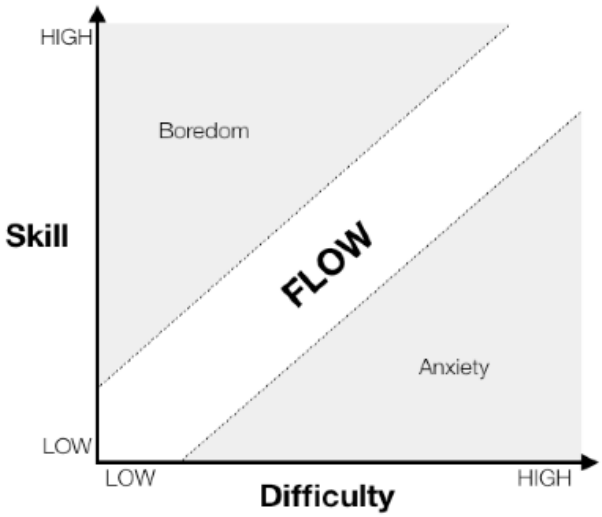

Fig. 1. Model of the optimal experience (theory of the flow) [19].

Ypsilanti et al. listed a number of aspects which should be taken into consideration during the development of games, in order to improve the perception and the benefits from a serious game [1]:

- Personal interest improve the associations from learning;
- Realistic content and situations allow to improve the perception;
- Bright graphics and information windows could attract the attention of the player to important aspects of the game;
- The game should be easily accessible for the regular user with minimum requirements for installation and gameplay;
- The game should include a tutorial;
- Serious games should be aimed at knowledge transfer, which means they should be very informative;

- Clear goals and expected results help to improve the learning impact of the game;
- Serious games should have clear and measurable indicators for success;
- The game should provide feedback to the player in order to adjust the difficulty level (neither too hard, nor too easy) in order to improve the motivation and maintain the attention;
- The requirements toward the focus of the player could be adapted according to the age of the player.

3. Review of the known serious games

There are numerous serious games on the market, which are aimed at different problems. Pixelearning has developed the game LearningBeans, which presents a detailed scenario for management of a manufacturing company [16]. The manufacturing cycle includes production, sales, marketing, human resources, finances, distribution and planning of the export, and shows the interconnections between the different aspects of the business. Another Pixelearning games is "The retail game", which aims to show the lack of skills in the sales sector of the United Kingdom and to improve the education of the British teenager. The goal of the game is to increase the sales in a simulated environment. It also has a public high score list, which allows friends to compete with each other.

The Cisco Company has developed six free educational games aimed at people looking for education through engaging games and challenges, which present different aspects of the communication systems. [16, 20]: San Rover, IPC Rockin' Retailer, Subnet Slingshot, Wireless explorer, Network defenders and Secure volunteer. A similar flash game was developed by Intel, which aims to show the importance of IT security through a criminal storyline [16].

British Telecom is offering an educational game named "Better business game", which aims to present different concepts and business strategies through simulators [21]. The game itself is of type monopoly and allows the players to compete in the creation of a business, using a certain initial capital. The game includes the main dilemmas which the business faces and shows how to take balanced decisions.

British Gas has created a simulator for education of engineers in the spheres of communication and diagnostics [16]. It uses the engine of a commercial 1st person shooter game, which is modified into a 3D role playing game.

Similar approach is used in the game "The monkey wrench conspiracy", which uses the engine of a 1st person shooter game. Although the game was designed for education of mechanical engineers in using 3D CAD software, it offers an interesting storyline (the saving of a space station), which created an additional stimulus for performing the assigned tasks [16].

The project NOVA ROMA [22] is based on a model of ancient Rome around 340 AD. The goal of this project is to create a collaborative learning environment for children of age between 11 and 14 years old, and to support the interdisciplinary investigation as a part of the study and the social model for interactive learning. The ancient city of Rome is presented as a realistic 3D forum, virtual roman characters with which the player could communicate.

The game Racing Academy [23] is developed by Lateral Vision and Futurelab in order to support the learning in the engineering spheres and sciences. Racing academy is a massive multiplayer engineering simulation with racing cars and transport vehicles, which allows the students to create realistic virtual models of automobiles. The difference from other similar games is this game is based on real physical and engineering principles. Online instruments allow teams of players to cooperate and to compete through the internet.

Quest Atlantis (QA) [24] is another international project for teaching and learning, which uses a 3D environment with many users. The goal of the project is to develop a serious game for children aged between 9 and 16 years old, where they could perform different educational tasks, which should allow them to grow up as informed and responsible individuals. QA combines strategies used in the trade environment and is based on important conclusions from pedagogic investigations on the opportunities for education and motivation. The genre of the game could be categorized as adventure and a role playing game.

The University of Glamorgan works on a simulator, which is going to be used for education of bachelors in business research. The goal of the game is to engage, motivate and maintain the attention of the students. The genre of the game could be identified as role playing or adventure [25].

US-Nexus is a virtual environment which allows people at a great distance from one another to communicate. Every player is presented as an avatar, which could move in offices, towns, countries. The virtual worlds in US-Nexus are engaging and stimulating and could improve the existing communications and cooperation, by allowing different individuals and groups to perform different online learning activities, including lectures, discussions, causes, projects and labs [26].

4. Conclusion

In this paper was performed a review of the applications of serious games in education which showed that education through games has some significant advantages compared to traditional education. Some of them are the improved motivation and the ability to attract and maintain the player's attention. Nevertheless game based learning has negative aspects as well and could lead to health and psychological problems.

The previous studies showed that the main reasons people play games are for pleasure, for entertainment, for challenge, from curiosity and for communication. Additional motivating reasons are the desire to accomplish a goal, the ability to choose and control the situation, to compete and cooperate with other players.

There are many requirements which have to be met in order to maintain the motivation of the player, which can be best performed during the design of the game: to seek the personal interest, to create an interesting storyline, to define correctly the goals and tasks of the education, to find a balance between the player's skills and the game's difficulty. In order to accomplish these tasks the criterial which will be used for assessment of the results, should be defined at design time of the game. If possible these criteria should be adaptive depending on the different scenarios and the difficulty level.

At the time being there are numerous serious games in the spheres of economics, engineering and social sciences, yet they are usually not a mandatory part of the education of students. This is due to the conservative way of teaching on one side and the difficulties related with the achievement of balance between pedagogical requirements and motivational factors. In some universities serious games are used in economical classes, but as a whole there are no known applications of serious games in engineering specialties.

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