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VIDEO GAMES AS A LEARNING TOOL - POTENTIAL APPLICATIONS IN THE GRAPHIC ENGINEERING AND DESIGN STUDIES

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Abstract: *Throughout this research, evidence has been accumulating on the positive impact of educational games (serious games) on students' learning and achievement and the impact of non-educational games on different psycho-physical traits. Today's dynamic way of life and almost innate familiarity with technology opens many new possibilities for teaching and can facilitate a better understanding of specific topics. There are numerous applications of video games for educational purposes. This paper aims to give insight into these researches and propose potential applications in a Graphic engineering and design studies. There is not much literature describing and discussing applications of video games in this field of study, and only simulations for specific graphics-related processes are commercially available. Significant findings in various applications of video games are listed and discussed. Some game design guides for implementing video game technology as an educational tool in the field of Graphic engineering and design are proposed.*

Keywords: video games, education, gamification, edutainment

1. INTRODUCTION

Throughout history, games have been meant to enrich leisure time and provide a sense of advancement and fulfilment by following specific rules and overcoming obstacles. Play, on the other hand, is usually not bounded by externally imposed rules and is more casual, creative, and liberating. However, that does not mean participating in a game cannot be playful. Our educational system is, by analogy to games, also founded on a different set of rules meant to be obeyed. By following these rules and overcoming various obstacles throughout studies, students acquire specific achievements after which they should be prepared for the challenges of the real world. Suppose the educational system is looked at in this way. In that case, educators can be found to be in the position to tailor their "mini-systems" to be similar to games or even to incorporate different kinds of games for better understanding, engagement, and learning. Guided by this premise, over the last three decades, there have been discussions about the influence of gaming on learning in students of various ages. Games are also studied as a tool for adult professional education and training.

There are various definitions and debates of what the game is. According to some scientists (Dempsey et al., 1996; Malone, 1981), a game is defined as “usually a contest of physical or mental skills and strengths, requiring the participant(s) to follow a specific set of rules in order to attain a goal.” Prensky (2001) defined a game as organized play, including six critical structural elements: rules, goals and objectives, outcomes and feedback, conflict/competition/challenge/opposition, interaction, and representation or story. What differentiates a game from a simulation is that it usually involves competition and is not necessarily a strict replica of reality. Rogers (2014), in his book “Level Up - The Guide to Great Video Game Design”, cites a few definitions of game proposed in academic circles: “a game needs to be a closed formal system that subjectively represents a subset of reality”; where “players are in conflict with each other.” Suits (1978) wrote that “playing a game is a voluntary effort to overcome unnecessary obstacles”, but ultimately Rogers gave his definition of a game: “a game is an activity that requires at least one player, has rules, has a win and/or lose conditions”. To answer a question what the video game is Roger said that: “a video game is a game that is played on a video screen”.

To give these definitions of a video game a little bit of “soul”, Crawford (1984) stated that: “The computer game is an art form because it presents its audience with fantasy experiences that stimulate emotion.” and that games are “intrinsically participatory in nature” which gives players “not the experience itself but the conditions and rules under which the audience will create its own individualized experience.”

For purposes of this study, games can also be defined as "a voluntary activity structured by rules, with a defined outcome (e.g., winning/losing) or other quantifiable feedback (e.g., points) that facilitates reliable comparisons of in-player performances" (Klopfer, Osterweil, & Salen, 2009).
One cannot discuss games, not to mention what the fun is. The fun does not refer only to something amusing or simply the result of a leisure time activity. In his book "Flow: The Psychology of Optimal Experience," Csikszentmihalyi (2008) talks about the state in which we dive when doing something interesting to us or when we make something interesting even if it does not look like fun in the beginning. He called this state the "flow" state in which even assembly workers can find themselves if they establish hourly goals and try to beat their best times. Young et al. (2012) stated that if work can be fun, the game can also be work (e.g., professional sports).
This paper aims to give insight into research done in the field of implementing games for educational purposes and what are some of the advantages and disadvantages of using games in education in the last decades. After this initial part of the study, suggestions about potential applications in Graphic engineering and design studies are discussed.

2. LITERATURE REVIEW

In this section of the paper, research that unveils valuable theoretical information for explaining some basic terminology used in studies about gaming for educational purposes is gathered and reviewed. One of the common misconceptions is that simulation and games, or even more often, simulation and simulation games, are synonyms. To understand how to implement games in the university curriculum, educators should also be aware of how games are related to learning process and the upsides and downsides of this approach in education.

2.1 Simulations and simulation games. Serious games.

Simulation can be defined as a "representation of reality or some known process/phenomenon "(Deshpande & Huang, 2011). It is a mathematical or algorithmic model with an appropriate set of constraints that allows predictive system analysis (Ochoa, 1969).
A simulation game, on the other hand, is a simulation with elements such as score, performance rating, conflict, and payoff, but which still simulates an actual world situation for decision-making or alternate evaluation (Deshpande & Huang, 2011). Simulations and simulation games allow the player to experience some process and engage in it without the risk of expensive mistakes. If a simulation involves competition (players with themselves or other players), it can be considered a simulation game. However, if the focus of a simulation involves only the completion of an event, it cannot be considered a game (Ke, 2009).
A serious game is a term coined by Abt (1987) in his book "Serious Games", and it can be defined as games whose primary purpose is education rather than entertainment. They are designed to teach academic content and skills to students playing them (Mayer, 2014).
Serious games are, to this day, successfully applied in healthcare, education, military, defence, ecology, etc. for teaching, training, raising awareness, changing attitudes and behaviours purposes and their target audiences include all ages (Daoudi et al., 2021). They are applied in primary, secondary and higher education in different disciplines such as computer architecture (Tlili et al., 2015; Hsu & Lin, 2016), mathematics (Ke, 2014; Chadli et al., 2019), science (Shute et al., 2016; Yang et al., 2021), computational thinking and programming concepts (Giannakoulas & Xinogalos, 2018; Theodoropoulos & Lepouras, 2020), history and language learning (Liu & Chu, 2010; Suh et al., 2010; Yang et al., 2010), and it is considered as alternative to traditional. Investigations of serious games have grown in the past 20 years, and today it represents an established academic field, as seen in Figure 1 (Gómez & Suárez, 2021).

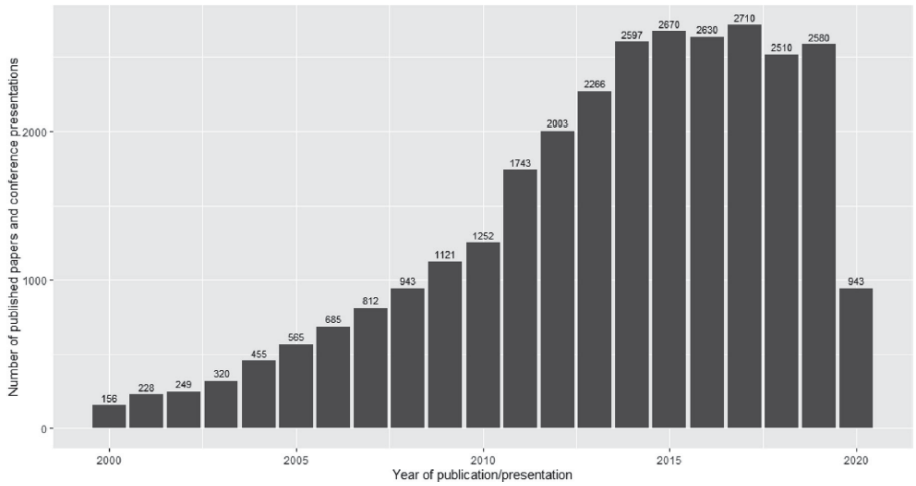

Figure 1: Number of research papers on serious games from year 2000 to 2020 according to Gómez & Suárez (2021)

2.2 Game-based learning

In the work of Piaget (1951), play and imitation are considered two crucial functions in a child's intellectual development process: play as an assimilation strategy and imitation as an accommodation strategy. Play is an important mediator for learning and socializing throughout life (Csikszentmihalyi, 1990; Provost, 1990). As a mediator of play, computer games should be looked at as an integral part of children learning and social lives.

Simulation games and problem-based learning represent experiential learning, collaborative, active, and learner-centric approaches (Deshpande & Huang, 2011). Both approaches include some assessment. In problem-based learning, self-assessment is conducted at the end of the problem or the learning cycle. The simulation game has a scoring system that indicates one's performance.

In game-based learning, students can be motivated to maximize their scores by trying alternative strategies and learning something new from the literature. Games can also be offered online, where advanced graphics and multimedia may be used to capture students' attention. In addition, help for the problems encountered in the game could be found online without waiting for the instructor to address the problem.

2.3 Advantages of using game in educational purposes

Using simulation games with authentic and situational problem-solving and instant feedback provide players with a realistic framework for experimentation and situational understanding and can act as essential primers for active learning (Laurel, 1991; Gee, 2003). In their study, Hitchcock (2000) concluded that computer-based simulation/gaming instruction increased motivation, attention, and learning retention. Motivation established through gaming can lead to engaged classroom culture (Barab et al., 2005)

Playing computer video games is more effective in facilitating third-graders' average learning outcome than text-based computer-assisted instructions (Chuang & Chen, 2009). Game-based learning in higher education can teach and reinforce skills necessary for future jobs, such as collaboration, problem-solving, and communication (Federation of American Scientists, 2006). In addition, game-based learning can motivate students by providing challenges, rapid feedback, and adapting to students' needs and interests (Council, 2011).

In the mobile game-based learning world, some efforts, such as Kahoot! application can yield promising results in engaging students in the learning process (Clark, Kirschner, & Sweller, 2012).

2.4 Disadvantages of using game in educational purposes

According to some research, the implementation of games is much more difficult in larger class sizes because they need additional space (Brown, 2018; Strickland & Kaylor, 2016; Graham & Richardson, 2008). Also, embarrassment or unwillingness to speak up and answer questions can arise (Boctor, 2019; Graham & Richardson, 2008). Also, some students that are not competitive can perceive competition in games as threatening (Blakely et al., 2008).

Some of the mentioned disadvantages of using games in the curriculum found in the literature are that there is an additional cost for supplies. Also, preparations for the class can be time-consuming for the faculty, and additional presence at the faculty may be needed (Kinder & Kurz, 2018; Strickland & Kaylor, 2016), as well as the amount of content needed to be covered (Boctor, 2019).

2.5 Approaches in using games in education

The report from MIT's Education Arcade (Klopfer, Osterweil & Salen, 2009) stated that researchers who advocate for game-based learning tend to adopt one of two very different approaches to designing games for formal education. The first approach is to use commercial games (e.g., World of Warcraft and Civilization) in education. The second one generally avoids commercial games and focuses on educational games that help supplement traditional academic subjects. Klopfer and colleagues (2009) pointed out that while "the first group embraces games and abandons school, the second group often embraces school to the detriment of anything that looks like real gaming." The two approaches mentioned above tend to be more instructional in the way that teachers want to have a finished, downloadable teaching product as the party responsible for teaching the child.
Kafai and Burke (2015) adopted and wrote about the constructivist approach to using games in education. Contrary to instructional approaches, the constructionist approach is learning by making games. In Piaget's (1951) work, games of construction are considered the highest form of gameplay, as games require children to build representations of the world according to their understanding. Kafai and Burke (2015) emphasize the idea that knowledge about rules, worlds, and interactions is, in this way, represented in a public entity (which is the game) and that playing and making games highlights the personal, social, and cultural dimensions of constructionist learning. They stated that making video games could help understand the social, economic, and civil power of making and sharing.

3. FINDINGS

This section of the paper will cover findings about the implementation of simulations in the field of Graphic engineering and design. After investigating selected literature, the next section will present the potential application of simulation gaming in the education process.

3.1 Using simulations in the field of Graphic engineering and design

Research papers and solutions regarding simulations and games in teaching graphic arts and printing are scarce. However, there are solutions for simulating some of the printing processes found during the research phase, such as Sinapse print simulators (Sinapseprint, 2017) and PrintSIM simulators (Printsim, 2022).
Sinapse print simulators represent interactive software that simulates the running of a printing press. They reproduce various printing conditions and problems that can be used for training, skills assessment, performance enhancement, and process analysis. Simulation can also familiarize other staff with the printing process, improve teamwork and increase process efficiency. Simulators are available for major printing processes such as flexography, sheetfed offset, gravure, heatset and coldset web offset (Sinapseprint, 2017).
One other simulation system is PrintSim. It was developed in 1987, combining knowledge of processes and know-how on teaching and course materials of partners from different parts of Europe (Printsim, 2022). PrintSim is an open, flexible simulation and multimedia system for learning printing processes, special situations, sequences, and modern automation systems. PostPressSIM is a computer-aided training system for bookbinding, finishing, and mailing which utilizes multimedia and three-dimensional virtual reality factory simulations. PrintSIM also provides a Course Generator that allows a teacher to write instructions for the trainee to use the system interactively without the teacher's supervision. PrintSIM also provides a database of questions and trainees' answers to help assess their work (Launonen, 1998).
According to Launonen (1998), the PrintSim, with its simulation and multimedia, has been very useful with good user feedback. Furthermore, courses enabled by incorporating PrintSim into training activities have indicated that multimedia and simulation are suitable for self-learning either as a private user or business company in the printing industry.
Saikumar et al. (2020) stated that knowledge gained by using simulations in the industry field minimizes risks and decreases costs, time, and energy for implementing a control system. These simulations can also

be used in the academic setting to promote understanding processes. In the work of Saikumar et el. (2020), the authors designed and simulated the automatic pad printing machine using CATIA software for 3D modelling and Automation studio for animation and simulation in a virtual environment. The virtual model is used for virtual commissioning.
These examples can be categorized as simulations, but not as simulation games due to the lack of some of the essential elements of the games, such as rules, goals and objectives, conflict/competition, win/lose conditions, representation, or story. One can argue that in these simulations, there are specific "rules" for running a printing press or that there are objectives, such as successfully running the machines. However, conflicts/competition or win/lose conditions are vaguely defined. Concerning representation, usually in these simulations, there are only some kind of user interface and rarely the exact 3D model of the observed printing machine, which can be observed in real-time, rotate around and interact with it. Moreover, there is no storyline besides strict theoretical explanations of the machines and systems.

4. DISCUSSION

For simulation to become a simulation game, all of the previously investigated elements of a game and approaches to implementing games in education must be considered carefully. The primary purpose of this process is to provide students with a realistic representation of the machines in the field of graphic arts. Also, to provide them with an immersive and enjoyable experience while exploring and participating in the game to increase engagement and ultimately equip them with practical skills and theoretical knowledge that will remain longer in their memory.

4.1 Possible solutions for using simulation games in the field of Graphic engineering and design curriculum

Using real printing machines in learning and training for special situations is very expensive (material and labour costs as well as the operating expenses of the press) and often impossible due to the risk of causing damage to the press. Purchasing a printing machine for training is a significant investment for most companies and schools. Even if resources are allocated for buying a printing machine, problems with available space for its installation can arise. Instead of using real machines, simulations can be used to train professional people in occupations where a human error would cost considerably or even be dangerous for their lives. Simulations provide risk-free education and practical knowledge for the trainee. It is possible to construct expert systems for complicated processes with many variables, such as in the printing industry. The purchasing costs of the simulation system are much lower than the costs of the corresponding printing press line, and usually, one system can serve several purposes or printing presses (Launonen, 1998).
In the article "Simulation software for training in the graphic arts," Launonen (1998) stated that new educational technologies are important to the graphic arts industry. However, getting new students into a vocational school is hard, and companies have difficulties recruiting new employees to their printing and finishing departments. These challenges are present due to the low work status, the night jobs in newspaper presses, and the lack of skilled craftsmen. They claimed that multi-skilled craftsmen would be needed in the printing industry in the future because of the wide variety of products and production machine types.
After years of experience in the education of graphic engineers and designers, there is still a great need for students' practical work on different machines in the printing industry because of the abovementioned issues. However, also there is a need for students' active participation in the learning process. The cognitive principles of educational technology should support metacognition and self-regulation or, in other words, reflective thinking rather than replacing students' thinking. Simulations should encourage problem-solving skills, and they should activate the user.
Technologies such as modern game engines (Unreal Engine, Unity, etc.), virtual reality, and augmented reality can help develop new simulations and interactions with otherwise expensive printing machines often unavailable to students. To acquire practical skills in the graphic arts industry, students need to have a chance to see and interact with printing systems and get familiar with the processes. Besides company visits which are very useful for getting a glimpse into the industry workflow, they cannot see all of the machines and systems that the curriculum includes, and they do not have the opportunity to try and work on the ones they saw. With the simulations, this can be overcome.

By introducing the “game” component into simulations, as seen from the literature discussed in this paper, students can interact on a whole new level, expanding the possibilities of their learning process and engaging them even more. Using modern game engines to make simulation games enables educators and students to build an immersive world of a printing house with machines from the graphic industry, which can help the learning process. Real-time graphics enable players of the simulation game to see exact replicas of the machines and provide interaction through coding, which provides immediate feedback. Students could explore, interact, and learn about these systems more engagingly. By using some scoring system or even a currency, students can learn how to operate and run the whole system and observe what implications it will have on their virtual economy. Every student can run their virtual print shop, follow how their virtual businesses advance, and later compare the results of the virtual printing game. In such a way, they can get as close as possible to practical experience, which is often hard to achieve in the real world.

Simulation games can also be created in the same game engines for future use in VR (virtual reality) or offer mixed reality experiences by employing AR (augmented reality). In this way, an even more immersive experience could be achieved to get the education as close as possible to one gained in real-world situations.

One more critical aspect of learning is learning by doing. By learning to work in modern game engines, students better understand the world they are building. By collaborating with other students and educators, they can build essential skills for future work in the industry (Kafai, 2015). This suggestion of making games for a better learning experience can be achieved by incorporating students' academic thesis and combining them in joint projects to build more complex virtual worlds and simulation games. A thesis done on subjects with different topics (3D modelling, game design, programming, and animation) can be combined in collaborative work. Even students' thesis from different departments can be used in a collaborative research project with the same ultimate goal - to build a better learning experience.

In Daoudi's (2022) work, the author suggests that a prerequisite to creating effective game-based educational systems is that researchers from different disciplines, such as computer science, educational science, psychology, and cognitive ergonomics, should work together. Also, collaboration between researchers, game designers/developers, and educators should be achieved to identify the best game usage to improve learners' achievements.

5. CONCLUSION AND FURTHER RESEARCH

Throughout reviewed literature, evidence has been accumulating on the positive impact of educational games (serious games) on students' learning and achievement and the impact of non-educational games on different psycho-physical traits. Today's dynamic way of life and almost innate familiarity with technology opens many new possibilities for teaching and can facilitate a better understanding of specific topics. There are numerous applications of video games for educational purposes. This paper aims to give insight into these researches and propose potential applications in Graphic engineering and design studies. There is not much literature describing and discussing applications of video games in Graphic engineering and design studies, and only simulations for specific graphics-related processes are commercially available. Significant findings in various applications of video games are listed and discussed.

From the statements mentioned above, it can be seen that to incorporate simulation gaming into the curriculum of Graphic engineering and design studies, knowledge and expertise from different disciplines should be combined. Artistic as well as technical skills are needed to accomplish this goal. Artistic skills include concept art, 3D modelling (in Autodesk 3D Max, Inventor, CATIA, etc.), and building virtual environments such as print shops where virtual machines would be located (Unreal Engine, Unity, etc.). Technical skills are also needed to get precise animations of the system and printing parameters which can be modified during the pre-printing, printing, and post-printing processes to get a representative simulation game. Industry experts should also be involved in this process to ensure that the functionality of the simulation game provides realistic feedback to the students. Finally, educators and game designers should ensure that all the necessary information is provided and delivered during the game. That simulation has game elements that provide a fun experience, realistic immersion in the game world, and challenges that students need to overcome to finish the game. Developers could provide a proper system for evaluating and assessing student progression.

This paper should be used to get familiar with the work done in applying games for educational purposes and as a starting point in implementing technologies from the gaming industry, such as game engines and

virtual headsets in the Graphic engineering and design curriculum. After the basic principles and approaches reviewed in this paper, further research should be done to propose detailed guidelines and best practices on incorporating game elements in simulation and combining knowledge from different branches of engineering and the art industry.

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