Serious Games Effect Analysis On Player's Characteristics

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ABSTRACT

"Serious games" refer to games that go beyond pure entertainment and promote learning. They are utilized within a variety of learning environments enabling students to acquire knowledge and skills, while they offer wide benefits. The authors' team measured and analyzed various factors related to the gameplay and educational content when 2D and 3D serious games are introduced in the educational process. The main objective focused on the correlation of the University students' views that were sharing common characteristics, like gender, information and communication technology skills, game playing experience, and specific scientific background with factors that related to the gameplay as well as the learning effectiveness. The results revealed that game-playing experience had a more positive impact in the case of males, while perceived learning effectiveness of 2D was higher compared to the 3D serious game for both genders. Moreover, there are differentiations among females concerning the scientific background, Information and Communication Technology skills and game-playing experience.

KEYWORDS

2D Serious Games, 3D Serious Games, Game Type, Game-Playing Experience, Gender, Higher Education, ICT Skills, Perceived Learning Effectiveness, Scientific Background, Serious Games

INTRODUCTION

Serious Games (SGs) are defined as "games that do not have entertainment, enjoyment or fun as their primary purpose" while the "seriousness" of these games refers to content that may clearly be used as learning material by teachers (Djaouti, Alvarez & Jessel, 2011). Although there is a perception that SGs are lacking fun or their primary purpose is other than amusement, Abt who was the first that used this term systematically, continued, arguing that, "this does not mean that serious games are not, or should not be, entertaining" (Abt, 1970, p.9). The main research aim of this work is to examine University students' views towards SGs features. Especially, we focused on a variety of factors such as gender, Information and Communication Technology skills, game-playing experience and specific scientific background i.e. natural and social, and their possible impact on game design (2D or 3D) regarding perceived learning effectiveness.

Well-designed SGs can boost learning outcomes and this can be expressed in a measurable way (Erhel & Jamet, 2019; Girard, Ecalle & Magnan, 2013; Granic, Lobel & Engels, 2014; de Freitas &

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Liarokapis, 2011). SGs learning and gaming components are ought to be well balanced in order to provide an immersive educational experience. Additionally, to the leaning and gaming balance, fun is also a very important feature of a good SG because it is supportive to engagement and motivational processes (Franzwa, Tang, Johnson & Bielefeldt, 2014; Kaimara & Deliyannis, 2019; Westera, 2019). SGs promote conceptual understanding through direct interaction and feature immediate feedback generated by the game environment (Boyle, Connolly & Hainey, 2011; Stapleton, 2004). The educational experience within an SG can be contrasted to actual game experience where the player assumes the role of the key character. Game-based environments are more immersive and engaging in terms of both technology and game design (Arnab, Berta, Earp, De Freitas, Popescu, Romero, Stanescu & Usart, 2012; Deliyannis & Kaimara, 2019). The game environment is enhanced with narration, hidden backstory and adventure or exploratory features (Faizan, Löffler, Heininger, Utesch, & Krcmar, 2019). Game interaction and feedback elements allow players to play and progress at their own pace (Federoff, 2002; Sweetser & Wyeth, 2005). On the other hand, SGs offer teaching tools to educators that motivate student's interest in the educational content. However, there are different challenges when SGs introduced into the classroom.

One of the major research fields is to understand how students interact with games and how learning occurs (Freire, Serrano-Laguna, Iglesias, Martínez-Ortiz, Moreno-Ger & Fernández-Manjón, 2016). Moreover, at the back-office level, learning analytics allow instructors to monitor students' activity and provide insight into their progress. Active use of this type of games to complement teaching can increase interaction and provide information that improves the contact time between students and teachers through personalization (Arthars, Dollinger, Vigentini, Liu, Kondo & King, 2019; Illanas, Gallego, Satorre & Llorens, 2008). Hu and Liu (2010) noted that users perceive mobile game differently with regard to computer game experience and gender differences. Most studies have indicated that males enjoy playing digital games more than females do. Moreover, they differ in their gaming motivations and content preferences while females dislike competitive, violent, or 3D digital games (Tsai, 2017). A recent report showed that gender differences in terms of how much time players spend playing games tend to disappear. However, this report did not provide any further details on the type of games that players prefer to play according to their gender (Statista, 2018). Taken into consideration the fact that the design and development of SGs are based on the adequate integration of educational and game design principles, as well as several studies provided evidence that students perform better while they are playing SGs, however, far fewer examined their effectiveness in the educational settings (Bellotti, Ott, Arnab, Berta, de Freitas, Kiili & De Gloria, 2011; de Freitas, 2018; Fokides, Kaimara, Deliyannis & Atsikpasi, 2019). For over a decade, teaching in higher education with the use of SGs has begun to concern researchers, although many of the institutions had not yet used this teaching method (Banks & McGinnis 2008; Liarokapis, Anderson, & Oikonomou, 2010; Vlachopoulos, & Makri, 2017). Within this framework, a survey which basic objective was to correlate university students' characteristics such as gender, Information and Communication Technology (ICT) skills, game playing experience and specific scientific background with their views towards the various factors related to the gameplay and educational content was conducted via clustering. For the purpose of our research, two games were examined, "ARTé Mecenas" and "Variant: Limits", developed by Triseum (https://triseum.com/), which are suitable for higher education training. Initially, in this paper, a brief literature review related to SGs is presented, methods and materials are further described and finally, research results are analyzed and discussed as well.

The main research problem examined relates to different students' characteristics and how those affect the way they perceive the learning effectiveness in relation to the type of the game in terms of its dimensionality: 2D and 3D. Other researches that examined the effectiveness of 2D and 3D game environments (Ak & Kutlu, 2017; Koops, Verheul, Tiesma, de Boer & Koeweiden, 2016; Zaharias, Chatzeparaskevaidou & Karaoli, 2019) for the same content report simmilar findings. In the present study, the differentiation was that we observed the same students' behavior even when the content of the game was different. For this purpose cluster analysis was utilized. The results within all clusters reveal that game design was an important factor, while 2D environments seem to be more effective than 3D. This finding could direct researchers to further examine if this evident was random and only concerns the design of the two specific games selected for the study, or it relates to the ability of the human brain to perceive dimensions in a alternative way regarding students' spatial cognition. Therefore, game environment dimensionality may be a potential factor that may affect the overall learning experience.

BACKGROUND

Serious Games in Higher Education

The scientific community is aware that there is a need for scientific and engineering methods for developing games as means that provide effective learning experiences (Belloti et al. 2011). This evidence requires closer collaboration between designers and developers involved in the general Game Development Life Cycle, putting pedagogy in a central role, given the educational goal of SGs. One of the first choices of the designer team concerns the definition of the target users and the elicitation of their needs. Thus, designing a SG needs the knowledge of learners' characteristics, learning objective, pedagogy and game design components (Suttie, Louchart, Lim, Macvean, Westera, Brown & Djaouti, 2012). Therefore, it is important to gather information about the way of a target population is playing a concrete game and its learning strategies. In this aspect, conducting qualitative and quantitative research as complementary methods is an efficient way to deeper understand the preferences, interests, and skills of the target group (Freire et al., 2016). The use of SGs is not widespread in several institutions, however, numerous researchers are taking into consideration their potential effectiveness in the case of higher education (Banks & McGinnis 2008; Liarokapis, Anderson, & Oikonomou, 2010). Despite that, this research field attracts a significant amount of interest from the scientific and educational community, as there is evidence that well-balanced SGs can promote learning with cognitive, behavioral and affective outcomes (Boyle, Hainey, Connolly, Gray, Earp, Ott, Lim, Ninaus, Ribeiro & Pereira, 2016). Moreover, it is acknowledged that games have a positive impact on learning goals, however, game-based learning environments are not widely utilized in the syllabus of higher education (Vlachopoulos, & Makri, 2017).

The environment of the SG can be either 2D (two-dimensional) or 3D (three-dimensional) or a combination of the two (Laamarti, Eid & Saddik, 2014). Educational game designers face the challenge to move from 2D to 3D environments (Terzidou, Tsiatsos, Dae, Samaras & Chasanidou, 2012). Various studies were explaining that the 3D Virtual Worlds (3DVWs) can provide a unique and flexible environment for teaching and learning without the restrictions of distance and space, with a wide range of online activities and massive multiplayer online gaming platforms (Ghanbarzadeh & Ghapanchi, 2018). In several surveys, although participants mentioned that both 2D and 3D SGs have a positive impact on their learning, the 2D version has a greater impact comparing to 3D (Ak & Kutlu, 2017; Koops, Verheul, Tiesma, de Boer & Koeweiden, 2016; Zaharias, Chatzeparaskevaidou & Karaoli, 2019).

Nevertheless, educational activities based on cutting-edge technology in higher education are less well understood by the educational systems. A systematic review conducted by Subhash and Cudney (2018) revealed that gamified learning in higher education started receiving attention from 2013 but grew rapidly thereafter. It is worth mentioning that most of the universities that have incorporated game-based learning in their courses, in fact, they have integrated gamification techniques namely game elements and mechanics, but not the use of games themselves. In order to explain the reasons why courses are not only conducted using SGs, it must be taken into account the cultural differences, attitudes, and perceptions of academics, educators and students as well as the high cost of games. For the purpose of our research, a survey considering the views of students towards multiple factors of 2D and 3D SGs, which were designed and developed for university level, was carried out.

MATERIALS AND METHODS

The main objective of this research was to analyze participants' views towards the provided SGs. Specifically, this study key goal was to examine whether students with common features had similar views and perception for the provided SGs. Participants' views were evaluated via a questionnaire. Clustering was achieved by grouping the retrieved data according to several common characteristics and the questionnaire's responses were analyzed under specified clustering that tested those perceptions. In order to follow the clustering procedure within the dataset, the two-step cluster analysis (TSCA) procedure was selected. For the TSCA, variables like gender, scientific background (social or natural sciences), ICT skills, game-playing experience, state of mind, technical features, content features. Moreover, due to the fact that learning impact is essential, learning effectiveness was also evaluated. The data was collected in accordance with the ethical rules of the Universities that participated, the games were played in the Departments' Laboratories and the completed questionnaires were anonymous.

Participants and Duration of the Project

Under this study, a total of 542 undergraduate students involved coming from Audiovisual Arts Department of the Ionian University in Corfu, Greece, as well as from Department of Primary School Education of the University of the Aegean in Rhodes, Greece. Students that participated in the study accepted a Facebook invitation which was posted on both departments official social network page or an invitation during academic courses where students were notified about this project. Potential participants were informed about the prerequisites in order to be able to participate in this project, namely, that was about to play one or two SGs, as well as, they had to complete a short questionnaire. Additionally, they were informed about the nature of this procedure namely that the survey was conducted on a voluntary basis.

Research Questions

SGs are suggested to empower students to acquire knowledge and skills. In this study, the research questions raised refer to the potential differences of participants' views that were sharing common characteristics, in correlation with factors related to the gameplay according to the type of the game (2D or 3D) and perceived learning effectiveness (Table 1).

Materials

For this project, two SGs developed by Triseum were chosen. Particularly, "ARTé Mecenas" was used, which is a 2D SG where players make decisions on behalf of the Medici family that affect the welfare of the Medici Bank and art history. The players needed to equilibrate relationships between powerful city-states, merchant factions, and the Catholic Church as they build their financial empire. Specifically, players had an essential role in order to create artworks, monuments, and institutions of the Renaissance.

The second SG that was used is a 3D game and it is named "Variant: Limits". In this game, students within this virtual world were using objects based on calculus principles and theories. In particular, this SG is involved with calculus topics i.e. initially finite limits calculation like basic limit calculation, one-sided limit calculation, and calculation of complex functions limits. Moreover, this game deals with function continuity, i.e. define a function continuity using limits in a specific point, complex function continuity control as well as intermediate value theorem. Finally, infinite limits are involved like calculating horizontal and vertical asymptotes using function limits.

Procedure

For the needs of this study, participants had to play one or two of the SGs in Departments' Laboratories. They were asked to play the chosen game for at least two hours. Both SGs included an introductory, or else tutoring level so that players could be familiarized with the game interface and the time needed

Table 1. Research questions

RQ1:	Does gender have an impact on perceived learning effectiveness considering the 2D SG?
RQ2:	Does gender have an impact on perceived learning effectiveness considering the 3D SG?
RQ3:	Does the scientific background have an impact on perceived learning effectiveness considering the 2D SG?
RQ4:	Does the scientific background have an impact on perceived learning effectiveness considering the 3D SG?
RQ5:	Do the ICT skills have an impact on perceived learning effectiveness considering the 2D SG?
RQ6:	Dooes the ICT skills have an impact on n perceived learning effectiveness considering the 3D SG?
RQ7:	Does the game-playing experience have an impact on perceived learning effectiveness considering the 2D SG?
RQ8:	Does the game-playing experience have an impact on perceived learning effectiveness considering the 3D SG?

for this part of the game was not included in the game(s) per se. Participants were asked to access and complete the provided questionnaire, as soon as they had completed the SGs playing procedure. The SGs were available for the students to play for a period of two months, from mid-January to mid-March 2018. Immediately after playing the games, they completed the questionnaire.

Questionnaire – Instrument

In order to collect additional data for qualitative and quantitative analysis, an online questionnaire was provided. Specifically, with the use of the questionnaire-based retrieved data, the educational digital material could be evaluated taking into account twelve subjective factors. These factors were clustered into three larger groups namely (a) state of mind (enjoyment, motivation, perceived relevance to personal interests, and immersion), (b) technical features (perceived realism, perceived audiovisual adequacy, and perceived ease of use), and (c) content features (perceived narration's adequacy, perceived goals' clarity, perceived feedback's adequacy, and perceived adequacy of the learning material). There were additionally several items examining perceived learning effectiveness. In order to conduct the subsequent data analysis, the average of each group was calculated. This questionnaire, apart from demographic information like age, gender, scientific background, ICT skills and game-playing epxerience, also included fifty-two Likert scale items statements. For these items' participants were asked to respond whether they agreed or disagreed with the provided statement in a five-point Likert-type scale (from strongly agree to strongly disagree). The questionnaire was considered to be reliable and properly structured (Fokides, Atsikpasi, Kaimara & Deliyannis, 2019a, 2019b). The validated questionnaire used for this study is presented in the Appendix.

RESULTS

Among the 542 participants, 303 participants played the 2D SG while 239 participants played the 3D game. 343 were undergraduate students enrolled at the Primary Education Department of the University of the Aegean and 199 were undergraduate students enrolled at the Audiovisual Arts Department of the Ionian University. It is worth mentioning that female participants were more compared to male: 66% and 33% respectively. In addition, more than 50% of the participants were aged between 19 and 23 years old, while only a few were more than 28 years. Most of the participants had a social science background namely 64% while 36% of them had an inclination towards natural sciences. Additionally, participants ICT-related skills, were measured to be above midpoint ($M = 3.58$, $SD = 0.80$), whereas their game-playing abilities almost reached midpoint ($M = 3.11$, $SD = 1.10$).

The study's main objective was to examine whether participants who shared some common characteristics had similar views for the SGs and, consequently, their replies to the questionnaire's items and factors were also similar. In order to reveal these natural groupings (or clusters) within the dataset, the two-step cluster analysis (TSCA) procedure was selected. TSCA is preferable compared to other clustering procedures (e.g., Hierarchical or K-means), because (a) it can analyze large data files efficiently, (b) it can create clusters based on both categorical and continuous variables, and (c) the number of clusters can be determined automatically (Norušis, 2008). Group analysis contains only descriptive information; it does not include statistical hypothesis testing and calculation of the level of significance of the findings. Therefore, it is acceptable to create clusters of data that may not satisfy the assumptions for better performance. It is at the researchers' discretion to determine if the solution satisfies their needs (Bacher, Wenzig, & Vogler, 2004).

The dataset was split in two so that the two SGs could be separately analyzed. For the TSCA, seven essential variables were included (a) gender, (b) scientific background (social or natural sciences), (c) ICT skills, (d) game-playing experience, (e) state of mind, (f) technical features, (g) content features. Also, since the impact on learning is a key factor in SGs, it was decided to include the perceived learning effectiveness as an evaluation field.

For determining the ideal number of clusters, the literature suggests that a good solution should have (a) a reasonably small Schwarz's Bayesian Criterion (BIC) and a large Ratio of Distance Measures (Mooi & Sarstedt, 2010), (b) the silhouette measure of cohesion and separation to be more fair or greater (Rousseeuw, 1987), and (c) the ratio of the sizes of the largest cluster to the smallest cluster to be below the 3.00 threshold. Also, one has to be reminded that clustering does not necessarily indicate statistically significant differences between clusters. Thus, the researchers have a certain degree of freedom to check different solutions and select a more meaningful number of clusters, even if their decision violates some of the above guidelines.

Results of the Cluster Analysis for the 2D SG

The cluster analysis for the 2D SG revealed that the smallest BIC value was for five clusters, whereas the highest value of the Ratio of Distance Measures also suggested five clusters (Table 2). Consequently, a five-cluster solution was considered as the most appropriate, as well as the more meaningful model. The resulting clusters had 45 (14.9%), 59 (19.5%), 71 (23.4%), 70 (23.1%), and 58 (19.1%) cases. The silhouette measure of cohesion and separation was .4, which was considered fair. Moreover, the ratio of the sizes of the largest cluster to the smallest cluster was 1.58.

The clusters with the characteristics differentiating each segment from the other are outlined below, while Table 3 summarizes the results.

Table 2. Auto-clustering, 2D SG

Number of Clusters	Schwarz's Bayesian Criterion (BIC)	BIC Change	Ratio of BIC Changes	Ratio of Distance Measures
1	1894.38			
2	1538.57	-355.80	1.000	1.64
3	1349.01	-189.56	.533	1.77
4	1271.357	-77.654	.218	1.17
5	1215.094	-56.263	.158	2.04
6	1222.504	7.410	-.021	1.34

- Cluster 3, 71 cases (23.4%). This cluster consisted of females having a social sciences background. Their ICT skills were the lowest among all groups ($M = 3.08$), while their game-playing experience were also the lowest ($M = 2.04$). This group gave the lowest ratings to all of the 2D SG's features ($M = 2.04$-3.07). Moreover, participants in this cluster gave the lowest score in the perceived learning effectiveness factor ($M = 2.63$), meaning that, according to them, the SG had a low impact on their learning.
- Cluster 4, 70 cases (23.1%). The second cluster included females also having a social sciences background. Their ICT skills were above the average ($M = 3.51$), while their game-playing experience were very close to the midpoint ($M = 3.04$). This group gave the highest ratings to all of the 2D SG's features ($M = 3.89$-4.10) and this also holds true for how they rated perceived learning effectiveness ($M = 3.83$).
- Cluster 2, 59 cases (19.5%). Males with a social sciences background were included in the third cluster. Their ICT-related skills were above the average ($M = 3.71$), while their game-playing experience were well below the average ($M = 2.97$). Although they rated all the SG's features well above the average, ($M = 3.49$-3.63), at the same time, they considered that the SG had an average impact on their knowledge, as the score they gave to perceived learning effectiveness was the second lowest among all clusters ($M = 3.16$).
- Cluster 5, 58 cases (19.1%). The fourth cluster consisted of females having a natural sciences background. Their ICT-related skills were well above the midpoint ($M = 3.71$), although their game-playing experience were below the midpoint ($M = 2.97$). As with the previous cluster, they rated all the SG's features well above the average ($M = 3.54$-3.79). What is more, their score in perceived learning effectiveness was the second highest ($M = 3.55$).
- Cluster 1, 45 cases (14.9%). The fifth cluster consisted of males having a natural sciences background. Their ICT and game-playing experience were the highest ($M = 4.09$ and $M = 3.93$ respectively). As with clusters 3 and 4, they rated all the SG's features well above the average ($M = 3.58$-3.72). Their score in perceived learning effectiveness was close to that of the 4th cluster ($M = 3.41$).

Results of the Cluster Analysis for the 3D SG

Coming to the 3D SG, the smallest BIC value was for five clusters, whereas the highest value of the Ratio of Distance Measures suggested three clusters (Table 4). A five-cluster solution was considered as the most meaningful model, after examining solutions with three up to six clusters. The resulting

Table 3. 2D SG, clustering details

	Clusters				
	3 $N = 71$	**4** $N = 70$	**2** $N = 59$	**5** $N = 58$	**1** $N = 45$
Gender	females	females	males	females	males
Scientific background	social	social	social	natural	natural
ICT skills	3.08	3.57	3.58	3.71	4.09
Game-playing experience	2.04	3.04	3.75	2.97	3.93
State of mind	2.71	3.86	3.49	3.54	3.58
Content features	3.07	3.95	3.63	3.67	3.72
Technical features	3.13	4.10	3.50	3.79	3.69
Perceived learning effectiveness	2.63	3.83	3.16	3.55	3.41

clusters for the 3D SG had 53 (22.2%), 68 (28.5%), 36 (15.1%), 45 (18.8%), and 37 (15.5%) cases. The silhouette measure of cohesion and separation was .4, which was considered fair. Moreover, the ratio of the sizes of the largest cluster to the smallest cluster was 1.89.

The clusters with the characteristics differentiating each segment from the other are outlined below, while Table 5 summarizes the results.

- Cluster 2, 68 cases (28.5%). This cluster consisted of females having a social sciences background. Their ICT skills were the lowest among all groups (*M* = 3.14) and the same applied for their game-playing experience (*M* = 2.54). This cluster's participants gave the lowest scores to all of the 3D SG's features (*M* = 2.72-3.14). Also, participants in this cluster gave the lowest score in the perceived learning effectiveness factor (*M* = 2.56).
- Cluster 1, 53 cases (22.2%). The second cluster included females having a natural sciences background. Their ICT-related skills were high (*M* = 3.81), while their game-playing experience were very close to the midpoint (*M* = 3.15). Although this cluster's participants rated all of the 3D SG's features slightly above up to well above the midpoint (*M* = 3.15-3.57), they rated perceived learning effectiveness slightly below the midpoint (*M* = 2.97).
- Cluster 4, 45 cases (18.8%). Males having a natural sciences background were included in the third cluster. Their ICT related skills were well above the midpoint (*M* = 3.69), while their game-playing experience were the highest among all clusters (*M* = 3.73). As with the previous cluster, they rated all of the 3D SG's features slightly above up to well above the midpoint (*M* = 3.04-3.46). Also, they rated perceived learning effectiveness very close to the midpoint (*M* = 3.04).
- Cluster 5, 37 cases (15.5%). The fourth cluster consisted of females having a social sciences background. Their ICT-related skills were high (*M* = 3.78), while their game-playing experience were slightly above the midpoint (*M* = 3.19). This cluster's participants gave the highest ratings to all of the SG's features (*M* = 3.68-4.15). Moreover, they gave the highest score to perceived learning effectiveness (*M* = 3.47)
- Cluster 3, 36 cases (15.1%). The fifth cluster consisted of males having a natural sciences background. Their ICT related skills were the highest among all clusters (*M* = 3.86), while their game-playing experience were the second highest (*M* = 3.61). Although this cluster's participants rated all of the 3D SG's features slightly above up to well above the midpoint (*M* = 3.14-3.50), at the same time, they rated perceived learning effectiveness below the midpoint (*M* = 2.83).

Table 4. Auto-clustering, 3D SG

Number of Clusters	Schwarz's Bayesian Criterion (BIC)	BIC Change	Ratio of BIC Changes	Ratio of Distance Measures
1	1513.18			
2	1250.00	-263.18	1.000	1.63
3	1114.23	-135.78	.516	1.77
4	1065.92	-48.31	.184	1.51
5	1055.98	-9.93	.038	1.23
6	1060.29	4.30	-.016	1.55

Table 5. 3D SG, clustering details

	Clusters				
	2 *N* = **68**	**1** *N* = **53**	**4** *N* = **45**	**5** *N* = **37**	**3** *N* = **36**
Gender	females	females	males	females	males
Scientific background	social	natural	social	social	natural
ICT skills	3.16	3.81	3.69	3.78	3.86
Game-playing experience	2.54	3.15	3.73	3.19	3.61
State of mind	2.72	3.21	3.04	3.68	3.19
Content features	2.93	3.25	3.33	3.70	3.14
Technical features	3.14	3.57	3.46	4.15	3.50
Perceived learning effectiveness	2.56	2.97	3.04	3.47	2.83

DISCUSSION

The results of the current study are summarized below. Each finding is contrasted to the trends and research evidence traced in the literature followed by a short discussion. Several researchers suggest that SGs games need to be immersive and highly motivating, in order to empower students and to promote their engagement under the learning procedure. In order to investigate the effectiveness of SGs in learning, it is necessary to inquire the students to whom these games are addressed. Therefore extended research, numerous of testing and data are required considering the various variables correlated to both students/gamers and the type and content of games themselves (Alsawaier, 2018; Falcão, e Peres, de Morais & da Silva Oliveira, 2018; Hamari, Shernoff, Rowe, Coller, Asbell-Clarke & Edwards, 2016). Important variables related to students/gamers are their age, gender, skills in using technology and devices, previous experience with digital learning games and their scientific background. Variables related to the type and content of games themselves could be the dimension, i.e. 2D/ 3D games and the syllabus, respectively.

In this case study, data suggest that the game-playing experience of males were better than those of females. On the other hand, the ICT skills of both males and females were quite good and not that different. Previous studies have shown that the time devoted to playing video games was significantly higher in males than females (Romrell, 2015). In 2018, however, it was estimated that women accounted for almost 45% of all players in the United States (Statista, 2018). Nowadays, video games have become increasingly popular among people of all ages and genders (Entertainment Software Association, 2018). These reports show that progressively males and females dedicate the same time to play games, but they do not provide more information about what kind of games they prefer.

In both SGs there was a cluster consisting of females having a social sciences background, low ICT skills, and low game-playing experience. The members of this cluster gave the lowest ratings to the SGs and they also considered them not effective in terms of learning by giving the lowest score in this factor, compared to the other clusters. Contrary to the above, in both SGs there was a cluster also consisting of females having a social sciences background, but with high ICT skills, and close to the midpoint game-playing experience. The members of this cluster gave the highest ratings to the SGs and they also considered them effective in terms of learning by giving the highest score in this factor, compared to the other clusters. Finally, in both SGs there was a cluster consisting of males having a social sciences background, high ICT and game-playing experience. The members of this cluster rated the SGs above the midpoint, but they rated perceived learning effectiveness close to the midpoint. Playing a video game is a highly self-regulated activity and mobilizes multiple sets of self-regulation related skills and processes (Yilmaz Soylu & Bruning, 2016). Self-regulating learning is referred to the learning process in which learners use self-regulatory skills such as self-assessment, self-directing, control and adaptation to acquire knowledge (Zimmerman 1989). Zimmerman, Bonner, and Kovach (1996) proposed a cyclical model of self-regulated learning, namely the Four-Phase Self-Regulated Learning model to demonstrate how learners actively use specific strategies to achieve the objectives of the course, based on their own willingness, motivation and metacognition. According to this model, there are four correlated processes: self-evaluation and monitoring, goal setting and strategic planning, strategy implementation and monitoring, and strategic-outcome monitoring. When more highly self-regulated learners face a learning task, plan how to achieve its learning goals considering their prior knowledge, beliefs, environmental structuring, time, and repertoire of study tactics. In our case, the Self-Regulated Learning Model underlines each player's self-efficacy according to its cluster. Expert game players used processes of self-regulation considerably more than less or non-expert players (Yilmaz Soylu & Bruning, 2016). Self-regulation is associated with self-efficacy.

Self-efficacy is the theoretical framework considering the students' confidence and beliefs with respect to their capabilities to perform specific tasks or activities (Bandura, 1986). Self-efficacy can be important for developing digital competence and for using technology in learning (Hatlevik, Throndsen, Loi & Gudmundsdottir, 2018). In this framework, when a player has more ICT skills and more gaming experience, both his / her self-efficacy and self-confidence are increasing. The case of cluster 5 is noteworthy (females having a social sciences background, but with high ICT skills, and close to the midpoint game-playing experience gave the highest ratings to the SGs and they also considered them effective in terms of learning). This finding is in contradiction with the current literature, whereby males seem to have greater self-efficacy in ICT than females (Hatlevik, Throndsen, Loi & Gudmundsdottir, 2018). There are many interpretations, mainly based on social stereotypes. However, there is a tendency for males to overestimate their competencies and females to underestimate them. The International Computer and Information Literacy Study 2013 (ICILS 2013) presented the ways in which young people develop Computer and Information Literacy (CIL) to support their capacity to participate in the digital age (Fraillon, Ainley, Schulz, Friedman & Gebhardt, 2014). CIL refers to the individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in the community. In their recent research, Hatlevik, Throndsen, Loi & Gudmundsdottir, G. B. (2018) found that girls obtained higher CIL scores than boys, also gilrs reported significantly higher levels of ICT self-efficacy than the boys and this result may indicate a change in previous gender stereotypes.

Concerning the game type, the perceived learning effectiveness of the 2D SG received higher ratings compared to the 3D in the case of the three groups of factors: the state of mind, content features, technical features clustering and in both genders as well. Nevertheless, in the case of the female participants having a social sciences background, high ICT skills, and midpoint game-playing experience considered both SGs' perceived learning effectivess. In both SGs there was also a third cluster having female members with high ICT skills, and close to the midpoint game-playing experience as in the previous cluster, but, this time, having a natural sciences background. The members of the third cluster gave above the midpoint scores to both SGs, they rated high the 2D SG in terms of perceived learning effectiveness, while their ratings fell below the midpoint in the 3D SG. Quite interestingly, a cluster with the same characteristics as the above but with male members was also present to both SGs. The research on perceived learning efficacy in relation to the type of games (2D/3D) has shown that the 2D game is considered more effective than 3D. Zaharias, Chatzeparaskevaidou and Karaoli (2019) have come to similar conclusions in their research. They noted that both 2D and 3D SGs had a positive impact on learning, however, 2D version had a greater impact comparing to 3D, regarding learning, while 3D version had a greater impact on motivation to learn and user experience. Ak & Kutlu (2017) also noted that the participants in their research valued 2D game-based environments more than 3D game-based and traditional classroom environments. One possible explanation is that three-dimensional models require greater working memory resources. Thus, the gamer has to process more information in a 3D game in comparison to a 2D game and hence more cognitive resources are needed for the gameplay (the primary task), leaving less cognitive resources for secondary tasks (Roettl & Terlutter, 2018). According to this evidence, it is suggested when educators are designing learning activities using 3D models, activities may have to be simplified to promote germane load as a compensatory strategy to ensure successful learning (Anderson, Jamniczky, Williams, Krigolson, Coderre & Hecker, 2019).

IMPLICATIONS FOR RESEARCH AND PRACTICE

Previous research has shown the important role that SGs in education. With the evolution of technology, increasingly attractive games are designed and developed, which are deeply immersive, represent the reality with great fidelity, and more and more dimensions are utilized beyond 3. However, when we refer to the SGs that their basic purpose is learning, necessary elements are not only technical parts such as the gameplay and mechanics but also the structuring of the relevant content which will be based on the combination of modern theories. SGs are essential to be understood by the educational community as an educational tool in a broader framework. According to Prensky (2003), at first glance, it seems that students/gamers learn to fly planes, drive fast cars, to be theme park operators, warfighters, civilization builders or veterinarians, etc. If however, we deepen, we are likely to find that students are learning significantly more: receive information from many sources, make decisions quickly, accept the rules of a game, design strategies to overcome obstacles, understand complicated systems through experimentation, and, increasingly, they learn to collaborate. Game-based learning is taking shape at colleges and universities as educators consider and use games in order to recreate experiences. Yet despite more advanced curriculum and several educational techniques and the finding that SGs contribute in substantial ways to the learning process, fostering engagement and boosting outcomes, they do not work autonomously but complementary to the course. The research findings suggest that 2D or 3D SGs could be utilized by the educational system.

LIMITATIONS AND FUTURE WORK

In this survey, participants were not asked to directly evaluate the type of the game so that we could have definite answers from the gamers themselves. The games that had been played do not share the same content. 2D is related to art history and 3D to mathematics. This is a limitation of the study because, in order to measure the perceived learning effectiveness considering the game type, the content should be stable and the only differentiation would be related to the construction of the game as 2D or 3D. In this way, we would be sure that what matters is the factor 2D or 3D rather than the content that relates either to the course of the art history or to mathematics. Another limitation could be the available time that the students had to play the games, that was approximately two hours. Again, the students were asked to play the games in the Departments' Laboratories, so the shared the same room and maybe this was a disruptive factor.

The results of this research were based on players' answers to a questionnaire designed to evaluate serious games. As Freire et al. (2016) pointed out that the majority of studies examined the influence of gender in the effectiveness of SGs with in-game assessments or in paper-based questionnaires. They proposed Game Learning Analytics, i.e. data collected in learning management systems, as an assessment that can effectively enrich the knowledge about why a particular game works better for males or females.

The above limitations serve as guidelines for future surveys by the researchers in relation to the type and content of the games. Authors' future work leans towards the additional implementation of the serious games in the learning process in primary, secondary, special education and in inclusive educational settings regarding various variables among which gender differences.

CONCLUSION

It has been argued that games are a very powerful way for people to learn. Additionally, SGs are regarded as an extremely functional and important component of the learning process. The development of 2D and 3D gaming environments provides developers and educators with high-quality applications that can, beyond a rich graphical experience, be highly sophisticated and support content customization and personalization during the learning process. The game-based learning process is integrated into life, which allows approaching content in a modern and less traditional way. In order to prove whether the use of SGs has positive learning outcomes, the students' point of view is essential. Thus, an important process of evaluating games is an assessment by the students themselves. Students' responses, depending on their scientific background, gender and experience with the use of games and technology in general, lead the entire design team to take their preferences and interests into consideration. Research results will be appropriately exploited as technology can adapt the content to the functional needs and skills of each user-student individually. With this in mind, our research team designed a questionnaire measuring twelve factors that are the key to identifying the user experience as a whole. A large sample of students from two different scientific backgrounds completed the questionnaire with several significant results regarding the type of games. Moreover, males and females with high ICT skills, midpoint game-playing experience, but with a natural sciences background considered 2D SG highly learning effective, while the 3D SG kind of low efficient. This work has independently verified what other researchers have already found regarding the role of gender and user abilities. In addition, two key facts were revealed: 2D game seems to be more effective in learning from 3D and identified the factors that are important to the player experience.

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APPENDIX

Table 6. The questionnaire's items

Factor	Item
Immersion	I was deeply concentrated in the application If someone was talking to me, I couldn't hear him I forgot about time passing while using the application I felt detached from the outside world while using the application
Enjoyment	I think the application was fun I felt bored while using the application* I enjoyed using the application I really enjoyed studying with this application It felt good to successfully complete the tasks in this application I felt frustrated*
Perceived usefulness -knowledge improvement	I felt that this application can ease the way I learn This application was a much easier way to learn compared to the usual teaching This application made learning more interesting I felt that the application increased my knowledge I felt that I caught the basic ideas of what I was taught with this application I will definitely try to apply the knowledge I learned with this application
Perceived narratives' adequacy	I was captivated by the application's story from the beginning I enjoyed the fantasy or story provided by the application I could clearly understand the application's story I was very interested in seeing how the events in the application will unfold
Perceived realism	When interacting with the virtual objects, these interactions seemed like real ones There were times when the virtual objects seemed to be as real as the real ones The virtual objects seemed like real objects to me When I used the application, the virtual world was more real than the real world
Perceived feedback's adequacy	I received immediate feedback on my actions I was notified of new tasks immediately I received information on my success (or failure) on the intermediate goals immediately
Perceived audiovisual adequacy	I enjoyed the sound effects in the application I think the application's audio fits the mood or style of the application I felt the application's audio (e.g., sound effects, music) enhanced my (gaming) experience I enjoyed the music in the application I enjoyed the application's graphics I think the application was visually appealing I think the graphics of the application fit the mood or style of the application
Perceived relevance to personal interests	The content of this application was relevant to my interests I could relate the content of this application to things I have seen, done, or thought about in my own life It is clear to me how the content of the application is related to things I already know
Perceived goal's clarity	The application's goals were presented at the beginning of the application The application's goals were presented clearly The intermediate goals were presented at the beginning of each scene
Perceived ease of use	I think it was easy to learn how to use the application I found the application unnecessarily complex* I imagine that most people will learn to use this application very quickly I needed to learn a lot of things before I could get going with this application* I felt that I needed help from someone else in order to use the application because it was not easy for me to understand how to use it* It was easy for me to become skillful at using the application
Adequacy of the learning material	In some cases, there was so much information that it was hard to remember the important points* The exercises in this application were too difficult* I could not really understand quite a bit of the material in this application*
Motivation	This application did not hold my attention* When using the application, I did not have the impulse to learn more about the learning subject* The application did not motivate me to learn*

Note. * = Item for which its scoring was reversed