Evaluating the Learning Process: The "ThimelEdu" Educational Game Case Study

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Abstract: Digital games are an important part of most adolescent's leisure lives nowadays and are expected to become the predominant form of popular culture interaction in our society. Many educators see digital games as powerful motivating digital environments, due to their potential to enhance student engagement and motivation in learning, as well as an effective way to create socially interactive, constructivist learning environments and educational processes based on each learner's needs. The present work focuses on how students acquire knowledge about the subject of the Greek ancient theatre through an interactive 3D serious game, compared with the traditional teaching process.

1 INTRODUCTION

Our century is characterized by the continuous growth of technology and integration of new and robust technological achievements in our everyday lives (Kalogiannakis & Papadakis, 2019). From health and science, to houses, people are using technology and computers for progressively simpler tasks. These robust changes have affected education and the way educational process happens, dramatically changing the view of traditional teaching classes.

Over the last years, an increasing demand for serious games has developed. Educational systems around the world, have transformed their processes, adopting the game-based learning model (Vidakis et al., 2019; Vidakis, Barianos, Xanthopoulos & Stamatakis, 2018). As part of the educational use of ICT, digital games become learning tools, motivators and generators of curiosity and as a result an effective means of optimizing student learning and performance in daily educational practice (Papadakis, 2018).

Researches have concluded that educational material that is presented through interactive games, increases learner's engagement and awareness for the educational process itself (Kalogiannakis, Nirgianaki & Papadakis, 2018). It is less possible for a student to renounce an educational process that motivates him. For instance, a primary school learner is more excited to learn historical events through a virtual environment with amusing graphics, animations and multimedia, rather than paying attention on the traditional classroom's blackboard or reading from his textbook.

Additionally, as digital games are an important part of most adolescent's leisure lives nowadays, they are expected to become the predominant form of popular culture interaction in our society. Many educators see digital games as powerfully motivating digital environments because of their potential to enhance student engagement and motivation in learning, as well as an effective way to create socially interactive and constructivist learning environments (Papadakis & Kalogiannakis, 2018).

The development of serious games that present educational material, can also help educators to create

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motivating, in and out of class, educational and assessing processes and therefore change old-fashioned exams and tests procedures. Furthermore, the evolution of portable devices has made it possible for learners to be part of an educational process from their homes, libraries and other study or leisure locations.

Our work focuses on the use of a serious game in a school class and its impact on student's knowledge compared to traditional teaching procedures. Students were asked to play a 3D interactive serious game called "ThimelEdu" (Vidakis et al., 2018; 2019). Through interaction with the 3D environment and its objects, students were taught about the Greek ancient theater. The educational material is presented through text, videos, questionnaires and images while students can navigate through the material using a 3D environment.

The rest of the paper is structured in the following sections: (a) background work presenting basic features about game-based learning and serious games, their results on the educational process and therefore on how students acquire knowledge, (b) an experiment where the traditional educational procedure is compared to the game- based learning model for the subject of the Greek ancient theater and its findings, (c) .

2 BACKGROUND

There is a growing appreciation that the conventional approach to the process of teaching does not address the social, emotional, mental and motivational needs of the new generation (Papadakis, 2018). The robust and continuous growth of technology has made students willing to use different technologies in ordinary usage. As Prensky mentioned, today's kids belong to the category of digital natives, comfortable with the digital age (Prensky, 2001a). In this perspective, the Information and Communication Technologies (ICT) are nowadays a trend in the field of education. The use of computer systems, computer applications, and ever more smart devices like smartphones and tablets during the learning process, has institute new standards in the way that students acquire and retrieve knowledge. As Prensky stated, students nowadays have developed assorted perspectives, in relation with non-computerized age students, and thus educational process needs to adjust to the requirements of this digital age (Prensky, 2001a; 2001b). Especially, the popularity of gaming in the dominant culture of the new generation has spurred the interest of the educational community,

with several educators and researchers seeking different approaches for using digital games in the classroom environment (Kalogiannakis & Papadakis, 2019).

Under those circumstances, the field of eLearning achieves traction and improvement day by day. The rationality, as well as the functionality of eLearning environments, has made it possible for teachers to provide and deliver knowledge and educational content to students across the globe, addressing the problems of distance and time (Gaur, 2018). The learning process through an eLearning environment can be achieved either synchronously, where the educational material is delivered in real time and educators and students can interact with each other, or asynchronously where there is no need for educators and students to be online at the same time and the material is stored and always accessible (Hrastinksi, 2008).

However, classic eLearning environments have shown their own issues. Lack of awareness and boredom has been observed through monitoring of students during an educational process with a classical eLearning module (Erhel & Jamet, 2013). The information overload, the lack of practice opportunities, as well as the lack of motivation present at sometimes, are some of the reasons that a student can easily and quickly fall behind in an online educational process. There is a point where the field of "Game based learning", can oversee this above-mentioned obstacle and provide an immersive learning experience in a virtual environment where learners can acquire knowledge in a recreative way.

2.1 Game-based Learning

Over time, educators concluded that repeated or periodical exams do not successfully evaluate a learner's grip of a subject and its application. Digital games are gaining wide recognition as an effective way to create socially interactive and constructivist learning environments (Papadakis, 2018). Alternative teaching methods, like serious games and virtual worlds, are trying to replace the existing conventional teaching processes. This is a shift that is going on at an enduring pace over the past years. For the eLearning environments, there are needs of significant changes and they must be capable to provide new features, in order to keep learners fully engaged with the educational process. One of those features is the digital game - based learning, able to deliver educational material through interactive games through increased entertaining as well as relaxing methods (Prensky, 2001b).

In order to define an educational activity as a game, Teed & Manduca (2004) proposed the following:

a) <u>Competition</u>: Each game is consisted of some essential characteristics. One of them is the scoring. Players/learners are trying to complete tasks in order to gain score and therefore are inspired to upgrade their performance. Moreover, through games, learners cooperate to complete tasks that rise through gameplay.

b) <u>Engagement</u>: The gameplay's graphics, animations, music together with the appropriate storytelling, makes learners / players engaged with the game and excited. Thus, it is less likely to give up until the whole game is over.

c) <u>Rewarding</u>: Players and therefore learners get energized when a game rewards them with points for completing a task.

Based upon those motives, game-based learning utilizes the use of game mechanisms, in the context of non-game concepts. Students can easily engage with gaming environments, that combine multimedia with different educational materials. Moreover, they can revise educational material by playing a specific part of the game multiple times. The concept of game-based learning was developed with the philosophy of providing the educational material through an entertaining and relaxing game, so students can acquire knowledge, retrieve it and manipulate it in an appropriate way to solve real world problems (Mouaheb, Fahli, Moussetad & Eljamali, 2012).

Comparing traditional with game-based learning, it is clearly noticeable that (a) students' awareness for the subject, (b) the ways that acquire knowledge and apply the subject in the real world are elevated with game-based learning approach and that game-based learning heads off a new era beyond the traditional learning.

Table 1 Comparison between traditional and game-based learning (Jaypuriya, 2016).

	Traditional Learning	Game-Based Learning
Cost	✓	✓
Low physical liability	✓	✓
Traditional assessment	✓	✓
Deeply engagement		✓
Apply knowledge in real world problems		✓
Feedback and response		✓
Knowledge acquisition is based on the learner itself		✓

Learners are willing to learn more and more if the material is presented in an exciting and interactive manner instead of traditional paper and white board ways. Moreover, playing educational games cannot take place only inside the classroom but learning sessions can move outside the classroom as well. Learners can play games anywhere desired without spatial boundaries. Nowadays, with the rise of smart devices, cloud computing and game technology, the development of classrooms and learning sessions outside traditional classes is an easy task. Games have incorporated, traditional and innovative assessment procedures while learners are engaged in assessment before, during and after the learning session with the educational game.

2.2 Serious Games

As discussed so far, there is a need for developing classes that deliver the educational context through interactive games, on which the whole educational process will be based. Those games are called serious games. By definition, serious games are educational interactive games with primary objective to educate and train and secondly to entertain (Vidakis, Syntychakis, Kalafatis, Christinaki & Triantafyllidis, 2015). Industries such as military, health, science, education and even politics, are using serious games as the origin of their instructive process. Since this work is discussing the computerized age, we will limit our thoughts to the field of "Digital serious games" in education.

As stated before, game-based learning makes learners engaged in the educational process and increases their interest and curiosity about the educational material. Serious games provide an interactive environment, consisting of graphics, multimedia, actions, animations, sounds etc., visualizing the educational content in an exciting and amusing way, rather than the traditional black board in the classroom (Vidakis et al., 2018). By those means, the term "Edutainment" has come up. Edutainment uses principles to link education and learning with entertainment, changing the classical nature of the educational process.

Games' industry nowadays is growing and provides multiple devices capable for playing games. From computers, to game consoles like PlayStation or Xbox, to smart devices, like smartphones and tablets (Vidakis et al., 2019). In the field of education, it is easier for learners to be part of an educational process based on a serious game, since they are, as Prensky stated, digital natives, as they have easy access on plenty of the mentioned devices

(Prensky 2001a; 2001b). Also, the fact that today's learners have grown up in a digital and computerized era makes them familiar with different aspects of technology and capable to use them fluently.

Serious games consist of five fundamental elements (Mautone, 2008):

Element-A) <u>Structure and Rules</u>. Game's structure, rules and boundaries, allow learners to face the consequences for adhering to them. Factors like directions, interactions, activities, rewards and penalties, configure an environment that provides different possible solutions for different goals.

Element-B) <u>Gamification</u>: Scoring, feedback given to learners for their pace to reach a goal. It varies from a straightforward affirmation that a specific activity or decision was correct, to information about what learners need to improve.

Element-C) <u>Tasks and challenges</u>: Different possible difficulties that learners have to face in order to complete a task and reach the required goal. Thus, learners are motivated to improve their skills and even more compete with other learners.

Element-D) <u>Instructional Support</u>: Assists learners how to gain knowledge from the game, practice and what the learning outcomes will be.

Element-E) <u>Aesthetics</u>: Visuals, graphics, animations, storytelling, role-playing and imaginary stories, excite and engage learners with the educational material.

However, for serious games to have an added value on the educational process, they must be coupled with an instructional strategy that engages, explores, explains, elaborates and evaluates (Hirumi & Stapleton, 2009).

Serious games can deliver knowledge via an amusing environment. Their components enable learners to interact with the educational material and gain or augment existing knowledge. The whole educational process has turned from teacher based to student based, where students are trying to acquaint with a subject by their own perspectives.

2.3 Cultural Heritage Serious Games

In the present work, we focused on the cultural heritage serious games, and more specifically for the Greek ancient theater and the impact that it has in students gaining of new knowledge. Places of cultural heritage are presented to the audience through virtual worlds and tours, for instance a museum's virtual tour. Based on this, serious games are able to engage audience with the virtual material and the educational content in an amusing way (Vidakis et al., 2018). Through the years, serious games have been developed for and supported mainly by places like schools, museums and archaeological places, with the purpose to educate students about cultural heritage.

2.3.1 Games and Tools

<u>eShadow</u>: A 2D collaborative platform that allows users to use tools in order to create, watch, share shadow theater plays. Users can also import their own puppets instead of using the existing ones.

<u>MUBIL</u>: This project aims to deliver, and present knowledge and content stored in the ancient assortment in the Norwegian Science and Technology University, where player is an ancient alchemy apprentice with a goal to produce a certain medicine.

<u>La Dama Boba Game</u>: Player is an actor and through puzzles and conversations re-produces the play "La Dama Boba, El juego".

<u>Acropolis</u> virtual tour: Developed as a web application that allows users to explore the archaeological site of Acropolis in Athens.

<u>The Ancient Theatre</u>: A web site that contains educational games for students and teachers about the ancient theatre and its god Dionysus. It contains the games: (a) "what is hidden under the city?" about the excavation and rebuild of the Larisa's ancient theater, (b) "the celebration of the great Dionysia", where users are part of a tour in ancient Athens during the Great Dionysia and (c) "A modern troupe in the ancient theaters of the world", where users can search around the globe for ancient theaters that being used till now.

2.3.2 ThimelEdu

In this work primary school students have explored and interacted with educational material about the ancient theater, through a 3D serious game, developed with Unity 3D game engine, called ThimelEdu (Vidakis et al., 2018). The nature of the theater studies is a challenge for the educators, because there is a difficulty in recreating situations and environments. Visits on sites can be difficult and sometimes impossible for students and the plays can be disinteresting to learners. Under those circumstances the ThimelEdu serious game was inspired and developed.

The main purpose of the game is to deliver educational content about the Greek ancient theater to students, as well as to be a complementary tool for the

educators who seek alternative teaching ways (Vidakis et al., 2019). The game is consisted of a 3D environment of an ancient theater where learners can navigate and discover building and tools used. Students cruise through and interact with the multiple scattered artifacts inside the site. The educational material is presented through texts, images and quizzes. Assessment is achieved through the possible questions presented during the navigation and interaction with the artifacts (Vidakis et al., 2019). Gamification characteristics, like score and rewards, are used to enhance players awareness and performance (Vidakis et al., 2018). Also, the game provides full accessibility by adapting its content and the game experiences, according to each learner's profile on the IOLAOS platform, ensuring the most ideal learning conditions for every learner (Vidakis et al., 2015).

Figure 1: ThimelEdu serious game (Vidakis et al., 2019).

3 OUR APPROACH

The purpose of the present study was to examine whether a game-based approach contributes to the development of students' knowledge compared to the 'traditional' teaching approach. A co-examination of the effect of additional factors, such as gender and age, was conducted while assessing the impact of the two forms of teaching intervention on the development of students 'knowledge according the ancient theater. We sought to examine the following hypotheses:

H1) The initial knowledge of the two groups will increase significantly after the intervention.

H2) The knowledge of students taught ancient theater elements with the 'traditional' approach is significantly less than the knowledge of students taught ancient theater elements with a game and is not affected by factors such as gender.

4 METHODOLOGY

4.1 Sample

After obtaining central office permission to conduct this study in school districts in the region of Crete, we contacted principals as per our institutional review board protocol to describe the study and request permission to meet with early childhood educators to explain the study and determine their interest in participating. The study adhered to university ethical guidelines. A common framework of ethical principles was adopted across the teaching intervention. Ethical principles relating to basic individual safety requirements were met regarding information, informed consent, confidentially and the use of data.

The research sample was ethnically and language homogenous and consisted of 22 students (8 boys, 14 girls) from the city of Heraklion, prefecture of Crete, Greece. The age of the student ranged between 17 and 17.5 years (M = 210 months, SD = 4.7 months, at the first time of measurement). The student attended two classes in a public High School during the 2018-2019 school year. Requirements concerning information, informed consent, confidentiality and usage of data were carefully met, both orally and in writing, by informing the school staff, students and parents on the purpose of the study and their rights to refrain from participation. Only children who completed all two rounds of testing (pretest, posttest) were included in

the final experimental sample. Students were randomly assigned to one of two groups.

4.2 Data Collection Instruments

For the evaluation of student's performance before and after the teaching intervention, a questionnaire was specially administered for the purpose of the current study. In short, the concepts examined by the questionnaire are identifying parts of the ancient theatre, understanding ancient theatre architecture, the role of orchestra, etc. Each of these elements is represented by a set of questions distributed across the test.

4.3 Research Design – Procedure

For the verification of the research hypotheses, an experimental procedure was designed, in which the sample was divided into two groups, the control group and the experimental group. The experimental design included three phases:
a) the pre-experimental control phase, during which the measurement of the dependent variable was performed,
b) the experimental phase/intervention, during which manipulation of the independent variable took place and
c) the post-experimental control phase, during which post-control of the dependent variable was performed.

The research procedure consisted of two stages. The first stage, from September to December of 2018, involved the pilot test of the game and the creation – evaluation of the questionnaire. The second stage, from January 2019 until May 2019, included the pre experimental procedure, the experimental intervention and post-experimental procedure. Student's regular mathematics classroom instruction was not interrupted by the study. In the experimental group, a computer game was used to enhance the regular classroom instruction, whereas in the control group the instruction was enriched with the use of WebQuest.

4.4 Students Pre-test

The first phase, which was common for the two groups, took place during January and February of the 2018-2019 school year. In this phase, students were asked to tackle the questions of the questionnaire. The evaluation lasted for 10 to 30 minutes, depending on the performance of each student. Students who were

absent on the days the tests were administered were not included in the sample.

4.5 Teaching Intervention

The teaching intervention took place between January and April of the 2018- 2019 school year. It aimed to develop student's general knowledge about ancient theater in general. The teaching intervention was done by the same teacher in both groups in accordance with the thematic approach, as defined by the Greek Curriculum of Studies for Secondary Education. In the control group, the teaching intervention was enhanced by using the web for a structured research (WebQuest), whereas in the experimental group it was enriched by using a special created computer game. Students who were absent for more than two teaching interventions were excluded from the survey. The second phase of the research was completed by the end of the teaching intervention.

4.6 Students Post-test

The third and final phase of the research was carried out in May of the 2018-2019 school year. During this phase, each student was examined once again in the questionnaire. For the proper conduct of the test, the same examination procedure as the one in the pre-test phase was followed.

5 RESULTS

Prior to data analysis, we ensured the typical assumptions of a parametric test such as normality, homogeneity of variances, linearity and independence were met before various parametric statistical tests can be properly used. The data were analyzed using IBM SPSS 23.0 software, and the significance level adopted was 5% ($p < .05$).

5.1 Equivalence Checking of the Experimental Groups

Initially, the equivalence of the two groups in terms of the student's gender was tested. The results, after applying the Chi-Square statistical criterion, showed that the two groups did not differ significantly in the number of boys and girls included, $\chi2(1) = 0.79$, $p > 0.05$. Subsequently, the equivalence of the two groups in terms of the student's age was tested. An analysis of variance showed that the two groups were equivalent as to student's age, $F(1, 20) = 0.1$, $p > 0.05$.

The one-way ANOVA was also used to investigate the equivalence of the two groups in terms of the average score in the questions, which describes the knowledge of the sample. According to the results of the ANOVA analysis, the two groups did not reveal a statistically significant difference in terms of the performance of student on the questionnaire before the start of the teaching intervention, $F(1, 20) = 0.3$, $p > 0.05$. Taking into consideration the aggregated results concerning the formation of the research teams, we conclude that both groups are equivalent in terms of: (a) age, (b) gender and (c) knowledge.

6 INFLUENCE OF THE EXPERIMENTAL INTERVENTION IN THE DEVELOPMENT OF ANCIENT THEATRE KNOWLEDGE OF STUDENT

6.1 Direct Effects of the Experimental Intervention in the Knowledge of Student

The main purpose of this study was to investigate whether student's performance in ancient theatre knowledge increased significantly, as recorded by their performance in the questionnaire, after teaching using a special designed game running on computers. For this purpose, both groups were compared as to their ancient theatre knowledge in the special created questionnaire before and after the experimental intervention, using dependent (paired samples) t-test. As the results presented in Table 1 reveal, the knowledge of both groups increased after the experimental intervention. The difference in the performance of students in each group during the two measurements is statistically significant.

To further investigate the first aim of the research it was considered useful to investigate whether these two groups differ on a statistically significant level with respect to the influence of the experimental interventions. For this reason, ANOVA analysis was conducted to investigate whether the groups differ on a statistically significant level. Specifically, the results of ANOVA showed a statistically significant difference in student's final performance in the questionnaire between groups, $F(1, 20) = 11.73$, $p = 0.0000$. Moreover, the mean of the improvement in the performance of the students in the experimental

group (21.45) is significantly higher than the mean of the performance of the control group (15.00).

Table 2: Results of the analysis of the t-test per group.

			M	*SD*	*t-test (df=10)*
Game based approach	Knowledge	Pre-test	*9.64*	*2.84*	*-7.49, p=0.000*
		Post-test	*21.45*	*4.44*	
			M	*SD*	*t-test (df=10)*
Traditional approach	Knowledge	Pre-test	*9.91*	*4.85*	*-6.34, p=0.000*
		Post-test	*15.00*	*4.41*	

6.2 Effect of Other Factors on the Development of Student's Knowledge

A key question in this study was whether the effect of the experimental intervention on the performance of the student in ancient theatre knowledge is affected by other factors. For the investigation of this research question a test of the degree of interdependence between the independent variables was conducted by using the Pearson product-moment correlation coefficient. The results indicated that there is no correlation between the age of student and the improvement of their performance in ancient theatre knowledge, $r(22) = -.014$, $p > 0.05$. Respectively, to investigate the effect of the gender of the student as a differentiating factor in the extent of improvement on performance in ancient theatre knowledge, a t-test for independent samples was applied. The results of the test showed that the effect of gender on the improvement in the performance of student's knowledge was not statistically significant, $t(20) = -0.37$, $p > 0.05$, namely, gender does not seem to influence in any way the improvement of student's performance in ancient theatre knowledge.

Additionally, there was a study of the effects of more than one independent variable on the dependent variable, namely the improvement in the performance of student's knowledge and the interactions between them. Initially, the main effects of the experimental intervention and student's gender on the improvement in their performance was examined through the criterion of factorial variance analysis. The results showed that the interaction between gender and the experimental intervention had no

effect $F(1, 18) = 0.91$, $p > 0.05$. Additionally, the main effects of the experimental intervention and the age of students on improving their performance were examined. The results from the application of the criterion showed that the interaction between the age and the experimental intervention had no effect $F(4, 9) = 11.75$, $p > 0.05$.

7 INVESTIGATION OF RESEARCH HYPOTHESES

The first hypothesis (H1) predicted that the initial performance in ancient theater knowledge of the experimental group and the control group would increase significantly after the intervention. Statistical analysis showed that both forms of intervention contributed significantly to the improvement of student's performance. As a result, the first hypothesis (H1), which refers to the positive impact of both forms of intervention on the improvement of student's ancient theatre knowledge was verified. The second hypothesis (H2) predicted that the performance of the experimental group and the control group in ancient theater knowledge would differ significantly after the intervention, depending on each form of intervention (game-based approach or WebQuest). In the intervention, where teaching with the use of a game was applied, student showed a higher final performance and a significantly greater improvement in their knowledge after the intervention compared to the control group. The above findings support the second hypothesis (H2). The third hypothesis (H3) predicted that the performance of the experimental group and the control group in ancient theater knowledge would differ significantly after the intervention, depending on the use of different forms of teaching intervention, even after the control of various other factors related to the development of their knowledge. The investigation of the interdependence of the independent variables on the extent of the improvement in student's final performance in ancient theatre knowledge showed that there is no correlation between age and gender on the extent of improvement in student's final performance. Additionally, investigating the main effects, as well as the interactions, of more than one independent variable on the extent of student's improved performance in ancient theatre knowledge showed that the effect of the experimental intervention did not differ depending on age or gender. Based on these results, the H3 hypothesis of this study was verified.

8 DISCUSSION

Many educators see digital games as powerfully motivating digital environments because of their potential to enhance student engagement and motivation in learning as well as an effective way to create socially interactive and constructivist learning environments (Kalogiannakis & Papadakis, 2019). The results of this study provide a framework for the formulation of pedagogical proposals which could develop students' knowledge in various disciplines in secondary education. Of course, technology is not a panacea. It is not the hardware or the software, but the combined use of ICT with the pedagogical approach that has the potential to make a significant contribution to student's specific knowledge achievement.

9 CONCLUSION & FUTURE WORK

To conclude, game-based learning is willing to create educational processes able to motivate learners and transform the traditional educational process to an effective and excited and entertaining procedure where learners interact directly with the teaching material (Mawas, Truchly, Podhradský & Muntean, 2019; Dorouka, Papadakis, & Kalogiannakis, 2020). Serious games are able to increase student's awareness about the teaching procedure and effectively transform knowledge (Papadakis, 2020; Rosli, Mangshor, Sabri, & Ibrahim, 2017). In the present work secondary school students taught about the Greek ancient theater through an interactive 3D serious game called "ThimelEdu". An experiment was held in order to examine if students acquire knowledge through a serious game, compared with the traditional learning method.

However, there were limitations on this study that need to be addressed in future studies. The duration of the teaching intervention was 13 weeks. Although it is adequate to test experimentally the effect of the different didactic approaches, it is not enough to fulfill student's needs in the development of their knowledge to a significantly greater extent. For this reason, it is necessary to implement a teaching intervention which will be long enough in duration to extensively investigate the effect of various didactic approaches in the development of students' knowledge. The second limitation of this research is that the study did not implement a delayed post-test

to measure whether knowledge gained from a game or WebQuest assisted learning approach persisted.

Finally, the implementation of a longitudinal study investigating the effects of different didactic approaches in the development of students' knowledge would also constitute a significant extension of the present study.

REFERENCES

Dorouka, P., Papadakis, St. & Kalogiannakis, M. (2020). Tablets & apps for promoting Robotics, Mathematics, STEM Education and Literacy in Early Childhood Education. *International Journal of Mobile Learning and Organisation*, *14*(2), 255-274.

El Mawas, N., Truchly, P., Podhradský, P., & Muntean, C. (2019, May). The effect of educational game on children learning experience in a slovakian school., *CSEDU - 7th International Conference on Computer Supported Education*, May 2019, Heraklion, Greece.

Erhel, S., & Jamet, E. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. *Computers & education*, *67*, 156-167.

Gaur, P. (2018). Research Trends in E-Learning. *Media Communique*, *1*(1), 29-41.

Hirumi, A., & Stapleton, C. (2009). Applying pedagogy during game development to enhance game-based learning. In *Games: Purpose and potential in education* (pp. 127-162). Springer, Boston, MA.

Hrastinski, S. (2008). Asynchronous and synchronous e-learning. *Educause quarterly*, *31*(4), 51-55.

Jaypuriya, P. (2016). How Game-Based Learning Redefines Engagement In eLearning. Retrieved from https://elearningindustry.com/game-based-learning-engagement-elearning

Kalogiannakis, M., & Papadakis, S. (2019). Evaluating pre-service kindergarten teachers' intention to adopt and use tablets into teaching practice for natural sciences. *International Journal of Mobile Learning and Organisation*, *13*(1), 113-127.

Kalogiannakis, M., Nirgianaki, G.-M., & Papadakis, St. (2018). Teaching magnetism to preschool children: the effectiveness of picture story reading. *Early Childhood Education Journal*, *46*(5), 535-546.

Mautone, T., Spiker, V., & Karp, D. (2008). Using serious game technology to improve aircrew training. In *Proceedings of the Interservice/Industry Training, Simulation & Education Conference (I/ITSEC)*.

Mouaheb, H., Fahli, A., Moussetad, M., & Eljamali, S. (2012). The serious game: what educational benefits?. *Procedia-Social and Behavioral Sciences*, *46*, 5502-5508.

Papadakis S., & Kalogiannakis, M. (2018). Using Gamification for Supporting an Introductory Programming Course. The Case of ClassCraft in a Secondary Education Classroom. In A. Brooks, E. Brooks, N. Vidakis (Eds), Interactivity, Game Creation,

Design, Learning, and Innovation. ArtsIT 2017, DLI 2017. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 229, (pp. 366-375), Switzerland, Cham: Springer.

Papadakis, S. (2018). The use of computer games in classroom environment. *International Journal of Teaching and Case Studies*, *9*(1), 1-25.

Papadakis, S. (2020). Evaluating a game-development approach to teach introductory programming concepts in secondary education. *Int. J. Technology Enhanced Learning*, *12*(2), 127–145.

Papadakis, S., & Kalogiannakis, M. (2019). Evaluating the effectiveness of a game-based learning approach in modifying students' behavioural outcomes and competence, in an introductory programming course. A case study in Greece. *International Journal of Teaching and Case Studies*, *10*(3), 235-250.

Prensky, M. (2001). Digital natives, digital immigrants. *On the horizon*, *9*(5), 1-6.

Prensky, M. (2001). The games generations: How learners have changed. *Digital game-based learning*, *1*(1), 1-26.

Rosli, M. S., Mangshor, N. N. A., Sabri, N., & Ibrahim, Z. (2017, October). Educational game as interactive learning for hurricane safety. In *2017 7th IEEE International Conference on System Engineering and Technology (ICSET)* (pp. 206-210). IEEE.

Teed, R., & Manduca, C. (2004, December). Teaching with Games: Online Resources and Examples for Entry Level Courses. In *AGU Fall Meeting Abstracts*.

Vidakis, N., Barianos, A. K., Trampas, A. M., Papadakis, S., Kalogiannakis, M., & Vassilakis, K. (2019). Generating Education in-Game Data: The Case of an Ancient Theatre Serious Game. In *Proceedings of the 11th International Conference on Computer Supported Education (CSEDU 2019)* (Vol. 1, pp. 36-43).

Vidakis, N., Barianos, K. A., Xanthopoulos, G., & Stamatakis, A. (2018). Cultural Inheritance Educational Environment: The Ancient Theatre Game ThimelEdu. In *European Conference on Games Based Learning* (pp. 730-XIII). Academic Conferences International Limited.

Vidakis, N., Syntychakis, E., Kalafatis, K., Christinaki, E., & Triantafyllidis, G. (2015, August). Ludic educational game creation tool: Teaching schoolers road safety. In *International Conference on Universal Access in Human-Computer Interaction* (pp. 565-576). Springer, Cham.