Game-Based Learning and Interactive Educational Games for Learners – An Educational Paradigm from Greece

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Abstract

Digital Game-based learning (DGBL) is an innovative concept that indicates how videogames can be used efficiently in the classroom for the benefit of learners. In the Greek educational system, post-gymnasium vocational education and training, level three - (3), is provided by the Vocational Training Schools and the Vocational Apprenticeship Schools of the Manpower Employment Organisation. This paper is a descriptive literature review with the basic aim to synthesize research and findings on the content of Digital Game-based learning and its potential to strengthen learners' motivation for learning. In addition, specifically chosen case studies of videogames are described, and in particular, Minecraft: Education Edition, Code.org and Tux Racer videogame platforms are examined in detail, to give answers on how they can become part of a meaningful and fun learning process with direct implementation to vocational education and training in the upcoming years. The selection of the following described three case studies was done with aim to describe videogames that were used in everyday teaching practice inside a classroom. Furthermore, game balancing is a very important mechanism in game design, and it is used to make games more enjoyable and engaging for users. Minecraft Education Edition is the most suitable edition for using Minecraft as an educational tool, and there are various lessons and kits for teachers and students to learn by having fun. Code.org courses are also designed with aim to motivate the active participation of students in the learning process. Tux Racer is a kart racing game where items are rewarded to the player-learner in the form of gift boxes and this game feature makes the game fun and enjoyable. From the findings, it is apparent that Minecraft: Education Edition, Code.org and Tux Racer can help learners to learn because they are fun, engaging and involve interaction with a user interface.

Keywords: game-based learning, educational games, game balancing

1. Introduction

Digital Game-based learning (DGBL) is an innovative concept that indicates how videogames can be used efficiently in the classroom for the benefit of learners (Wu & Wang, 2012; Hainey, Connolly, Boyle, Wilson & Razak, 2016; Triantafyllou, 2021). Video games can help learners to learn because they are fun, engaging and involve interaction with a user interface (Wu & Wang, 2012; Triantafyllou, 2023).

In the Greek educational system, post-gymnasium vocational education and training, level three - (3), is provided by the Vocational Training Schools and the Vocational Apprenticeship Schools of the Manpower Employment Organisation ("National reforms in vocational education and training and adult learning", 2022). The purpose of the above-mentioned schools is tackling school dropout, basic skills upgrading for compulsory education graduates or equivalent and integrating them into the labour market ("National reforms in vocational education and training and adult learning", 2022). This paper examines Minecraft Education Edition, Code.org and Tux Racer games, and tries to give answers on how these games can become part of a meaningful and fun learning process with direct implementation to vocational education and training in the upcoming years.

1.1 Game Balancing

Game balancing is a very important mechanism in game design, and it is used to make games more enjoyable and engaging for users. It is a game design mechanism that can be described as a mathematical-algorithmic model that combines game mechanics and game numeric data (Morelli, 2014). Numerous heuristic techniques are used to achieve dynamic game balancing, that means that a video game should provide meaningful options for the players to choose, and random game elements that are controlled in order to give the player the sense that the game is a fair and a continuously evolving process (Korhonen & Koivisto, 2007; Tijs, Brokken & IJsselsteijn, 2008; Triantafyllou & Georgiadis, 2022; Triantafyllou, 2022c).

1.2 Minecraft: Education Edition

Minecraft is a video game developed by Markus Alexej Persson in the Java programming language. In Minecraft, players discover a procedurally generated 3D world made of blocks and develop their creativity by building their own content (Lastowka, 2011). In addition, there are other benefits to be arisen from the Minecraft game. Character building skills such as collaboration, creativity and problem solving are all possible outcomes through playing. For instance, learners can build a representation of their own school by measuring it up and by estimating scales. They can propose hypotheses, collect data and produce research outcomes. Repeatable experiments can be run to collect data within the Minecraft environment (see Figure 1).

Figure 1: User-designed house with water feature

1.3 Tux Racer

Tux Racer is a racing video game developed by Jasmin Patry in the University of Waterloo, starring the Tux the penguin. It is a racing game where the player is responsible to direct Tux running across mountains. The options of the penguin are to turn left, right, slow down, jump, and paddle, and move his wings. If the player pushes the buttons to slow down and turn, the penguin will make a tight turn. If the player begins to use paddles, then gives the penguin some more acceleration and speed. By using puddles, the gained speed starts to go down and in turn decelerates the penguin when the speedometer displays the sign of yellow color. The player can also restart the penguin with his basic settings in case he stuck along the course (see Figure 2) (Tian et al., 2016).

Figure 2: Screen shot from Tux Racer (Simulation Game)

2. Methodology

Our study reviews research on the utilization of video games in schools and other learning environments with focus on the final learning outcomes. Our research methodology was based on the following stages:

Step 1: Presenting the Research Questions

The research question that is formulated for this research to contribute to a better understanding of Digital Game-Based Learning with focus on Minecraft: Education Edition, Code.org and Tux Racer video games and their usage and application in the class is:

(RQ): How can digital game-based learning and specifically Minecraft: Education Edition, Code.org and Tux Racer video games can be used in classroom to enhance the learning process?

Step 2: General Database Research

Consequently, to answer the research question proposed, a search was run across the relevant databases to find papers available in the literature.

Firstly, a search was conducted in the Google Scholar database to find documents on Digital Games-Based Learning with emphasis on Minecraft: Education Edition, Code.org and Tux Racer published from 2013 to 2022. The total number of publications amounted to 186 publications. After the initial search in the Google Scholar database, a more detailed and focused search process was conducted in Scopus bibliographic database to find more publications of high scientific rigor. The total number of publications in Scopus amounted to 83 with 41 conference papers, 32 articles, 7 conference reviews, 2 reviews and 1 book chapter. The final number of papers found in each bibliographic database, are presented in Table 1 and Figure3.

Table 1: Results of indexed papers in databases

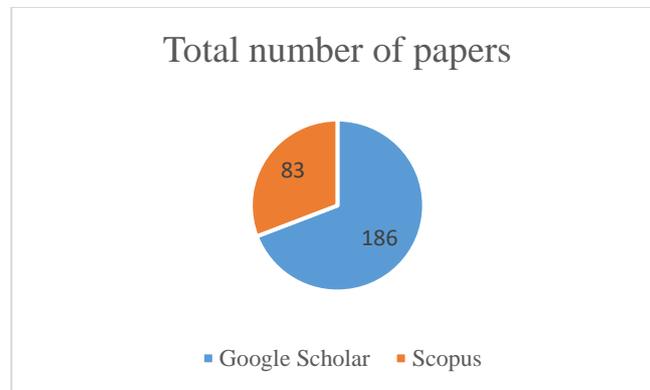| Databases and Digital Libraries	Total number of papers
Google Scholar	186
Scopus	83

Fig. 3. Number of peer-reviewed papers indexed in each database

Step 3: Selecting Papers

The abstracts of searched articles were reviewed based on a specific criterion that is to find more publications of high scientific rigor. Every paper that met these prerequisites was mentioned in this study, and for those papers that was difficult to decide to be excluded after the process of reading their titles and abstracts, the full text of every paper was reviewed. After conducting this process, the following documents were selected and are presented in Table 2.

Table 2: Selected Papers

Papers classification	Documents
Research articles, book chapters and reviews	(Hainey, Connolly, Boyle, Wilson & Razak, 2016; Wu & Wang, 2012; Andrade, Ramalho, Santana & Corruble, 2005; Morelli, 2014; Tijs, Brokken & IJsselsteijn, 2008; Korhonen & Koivisto, 2007; Lastowka, 2011; Tian et al., 2016; Michael Dezuani and Jo Macri, 2020; Prensky, 2003; Beavis et al., 2014; Coller & Scott, 2009; Morelli, 2015; "Code.org", 2022; "Summary of source data for Code.org infographics and stats", 2022; "Minecraft TimeCraft", 2022; Rexhepi, Filiposka & Trajkovik, 2018; Dalheimer et al., 2005)

Step 4: Answering the basic Research Question (RQ)

Digital Game-Based Learning can be described as a pedagogical approach that integrates digital games as educational tools (Prensky, 2003; Beavis et al., 2014, Triantafyllou, 2022a; Triantafyllou, 2022b). It is a learning and teaching approach that utilizes digital games or game-based environments to create engaging, enjoyable, and challenging tasks to achieve learning objectives and produce learning outcomes that can be objectively measured (Coller & Scott, 2009). Digital Games that are developed for a learning purpose focus on learning that takes place when the player interacts with the mechanics of the game.

The selection of the following described three case studies was done with aim to describe videogames that were used in everyday teaching practice inside a classroom. There is a special interest by authors for these three case studies, because they seem to bring positive results regarding students learning progress and their motivation for learning. With the following case studies that are described, some first learning outcomes are presented in the new and continuously evolving research area of Digital Game-Based Learning implemented via three game platforms that are Minecraft: Education Edition, Code.org and Tux Racer.

2.1 Case study to measure the impact of Minecraft: Education Edition in the subject of Mathematics

The researchers at the Queensland University of Technology's Digital Media Research Centre in Australia studied the impact that Minecraft: Education Edition can have for students as they learn mathematics (Michael Dezuani and Jo Macri, 2020). They examined in what ways the Minecraft can act as learning environment so as to build engagement, with focus on classrooms where the teachers are novice to the game characteristics. They collected data from 307 students and 14 teachers from 6 schools across Queensland, including two schools in Brisbane, one school in Toowoomba, one school at Gold Coast city, one school in a rural location in Far North Queensland and one school in a rural location in South East Queensland. The project emphasized on novice Minecraft educators, and the basic objective was to use usual resources with the teachers in the six schools. The implementation of the learning tasks was focused on the mathematics learning process and not to the technical issues related to the advanced Minecraft version. Consequently, the researchers in order the learning activities to be aligned with the Australian Curriculum, they have chosen the "*Algebra Architecture*" and "*Area and Volume*" courses. The "*Algebra Architecture*" course explores math models to learn about arithmetic patterns, and students use this knowledge to create architectural designs. "*Area and Volume*" incentivizes students to generate and try to solve problems concerning spatial mathematics, in the Minecraft digital environment. After three months, the students' progress was remarkable (see Fig. 4 and Fig. 5) (Dezuani and Macri, 2020).
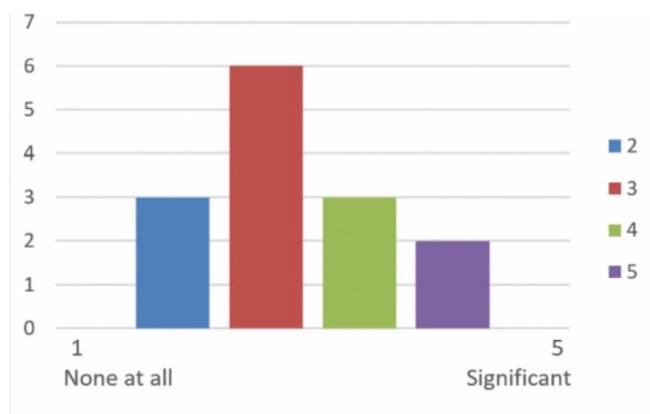
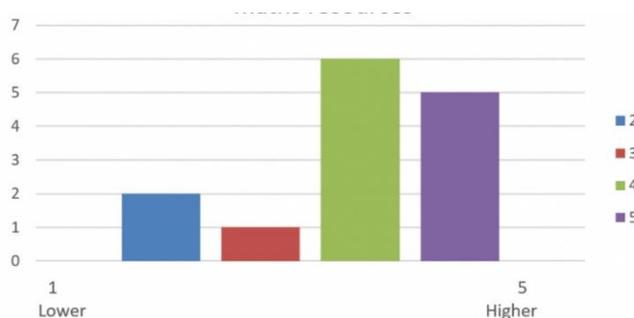*Fig. 4. Value added to Student Understanding by using Minecraft (Michael Dezuani and Jo Macri, 2020)*

Fig. 5. Comparison to student engagement with usual maths resources (Michael Dezuani and Jo Macri, 2020)

2.2 Case study of Code.org platform

Code.org is a nonprofit innovative educational project with main purpose to provide for all students the opportunity to learn computing as part of their basic K-12 curriculum. Code.org also takes the responsibility to organize the "*annual Hour of Code campaign*", which has engaged numerous students globally. Code.org is supported by Google, Amazon, Microsoft, and many others ("Code.org", 2022).

Because attending computer science is of great importance for almost every scientific field, Code.org courses are built to motivate the active participation of students in the learning process and there are no prerequisites or restrictions regarding knowledge or any specific technological background from the side of learners that are enrolled to the courses ("Code.org", 2022). Goals and metrics of Code.org are presented in Figure 6 and emphasize on making Computer Science a standard in education curriculum.

Code.org Goal	Accomplishment
Improve diversity in CS (*US students*)	45% of Code.org students are young women, 50% are students from marginalized racial and ethnic groups, and 45% of US students are in high needs schools. Read more about **our approach to diversity**.
Inspire students	Tens of millions have tried the **Hour of Code**. (1,465,295,655 served. 49% female)
Reach classrooms	2,246,709 teachers have signed up to teach our intro courses on **Code Studio** and 72,359,995 students are enrolled.
Prep new CS teachers	We've prepared more than 106,000 new teachers to teach CS across grades K-12. Learn about our **professional learning programs**.
Change school district curriculum	We've partnered with **180+ of the largest school districts** and 60 regional partners to **add CS to school curriculum**. Learn about **becoming a regional partner**.
Set up policies to support CS	**Policies changed in 50 U.S. states** to establish CS education standards, make CS courses count towards high school graduation, etc. (**details**)
Go global	Our courses are available in over 67 languages, used in 180+ countries.

Fig. 6. Code Studio Activity and surveys of participating educators ("Summary of source data for Code.org infographics and stats", 2022)

Minecraft TimeCraft is an online tutorial in Code.org with basic aim to incentivize learners to start to code. The "*Minecraft Hour of Code*" tutorial is included in "*Minecraft: Education Edition for Windows, Mac, Chromebook, and iPad"* with free educative tools to use (see Figure 7 and Figure 8). By using Minecraft, students can build a creative and problem-solving skillset to explore and construct worlds under the water by writing code.

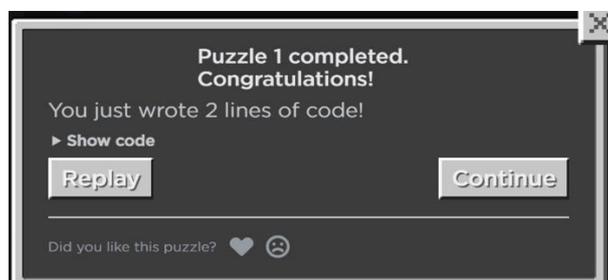*Fig. 7. Screen shot from Minecraft: Voyage Aquatic*

Fig. 8. Screen shot from Minecraft: Voyage Aquatic (Puzzle 1 completed)

In addition to the above-mentioned tutorial, teachers can use App Lab and Game Lab in any course to teach students how to learn to code in JavaScript ("Minecraft TimeCraft", 2022). In "*Professional Learning for Middle and High School Teachers*" (2022), there is the following statement that:

"*More than 100,000 teachers have participated in the Code.org Professional Learning program, and the majority of attendees rank it as the best professional development ever. Over 90% of attendees would recommend the Code.org to another teacher*".

2.3 Case Study to measure the impact of Tux Racer

Tux Racer is a kart racing game where items are rewarded to the player in the form of gift boxes and this game feature makes the game fun and enjoyable (Morelli, 2015). Also, when the player finishes first a number of laps, then the player gets as a reward a bonus prize. The prize is increased steadily and not randomly, so that games that have more real players than computer-controlled opponents, to earn a bigger final prize.

Linux as a multimedia platform, introduced with Tux Racer an open-source racer game where the player can watch the Tux to slide on the mountainside at 90km/ph in a realistically rendered graphic area. The game became famous and led to the development of a commercialized release.

"*Tux Racer*" lets the player to be "*Tux the Linux Penguin*" as he drives through the mountains. Tux enters a mission (cup) and competes to be the winner of the title. It is not a simple game but a platform through which the learner can experience virtual situations, try out strategies and simulate new ideas. With Digital Game-Based Learning and combining educational content with the Tux Racer video game, the student is encouraged to actively participate in the learning process. Tux Racer is a characteristic example on how Digital Game-Based Learning can be beneficial for students of every age. Students can accomplish basic learning objectives and have fun during the learning process by learning through gameplay. A game-like characteristic that brings joy, is the existing game balancing, which allows novices and more experienced players to compete against each other. During the gameplay it seems that if one player is the first car racer, the items he/she obtains have not so much power than if

he/she is the last. The penguin Tux rides down the snow slope and collects as much fishes as he can. Sliding on ice gives speed to Tux. However, rocks and crashing into trees slow him down (Dalheimer et al., 2005). The player collects points by eating fishes, and if the time the player finishes the race is faster, the score is bigger. Game progress is achieved by fulfilling three requirements: collecting the sufficient number of fishes, finishing the race in a predetermined time, and getting many points. When the player fails to meet these requirements, these actions cost a life, and if the user that plays lose exactly four game lives, then he/she must restart the game mission (Morelli, 2015).

3. Suggestions for Future Research

The adoption of technology in vocational education and training is changing the way of teaching and learning in many ways. Specifically, the adoption of Digital Game-based learning (DGBL) in school curricula can bring many positive learning outcomes and help every learner to develop critical thinking and problem-solving skills. Minecraft Education Edition, Code.org and Tux Racer are characteristic examples of games that can be the vehicle that can lead to learning success, when properly used for a computer science course according to learners' needs and their learning experiences. Therefore, further scientific investigation of Digital Game-based learning is the basic aim of future studies.

4. Conclusion

Through this study, some basic conclusions are drawn. In the first place, Digital Game-based learning (DGBL) is an innovative concept that indicates how videogames can be used efficiently in the classroom for the benefit of learners (Wu & Wang, 2012; Hainey, Connolly, Boyle, Wilson & Razak, 2016, Triantafyllou, 2021). Video games can help learners to learn because they are fun, engaging and involve interaction with a user interface (Wu & Wang, 2012, Triantafyllou, 2019; Triantafyllou, 2022b).

This paper examined how Minecraft Education Edition, Code.org and Tux Racer can become part of a meaningful and fun learning process. "*Minecraft: Education Edition*" is designed for education inside the classroom. It provides teachers with the necessary technological tools to design a meaningful and engaging course that supports interaction. Minecraft Education Edition is the most suitable edition for using Minecraft as an educational tool. There are various lessons and kits for teachers and students as options, like: (i) "*Coding fundamentals and python*", (ii) "*Food production and energy systems*", (iii) "*Sustainability and recycling*", (iv) "*Space exploration and planetary systems*", (v) "*Energy transfer, forces, units of measurement*", (vi) "*Writing and language arts*", (vii) "*Historical events and geography*", (viii) "*Math for all grade levels*", (ix) "*Art and design*". In addition, there is also a program called "*Engineering For Kids*" which is a summer camp named "*Urban Innovations with*

Minecraft". In this camp, students can play, imagine and design a sustainable city (Rexhepi, Filiposka & Trajkovik, 2018).

Code.org courses are built to motivate the active participation of students in the learning process and it should be mentioned that there are no prerequisites or restrictions regarding any specific technological background from the side of learners that participate to them.

"*TuxRacer*" is a 3D racing game, and the gameplay includes missions of running down a mountain slope, avoiding obstacles and collecting fishes. It is a kart racing game that can be used to identify the basic characteristics of games and interactive systems. Game-based learning (GBL) is a strategy that uses the idea of a playing game to accomplish specific learning objectives. Tux Racer when properly used in a school classroom can enhance students' motivation for learning and help them to learn new technologies and accomplish learning goals (Anderson, 2000; Dalheimer et al., 2005).

References

Anderson, Lee, (2016). "Game review – TuxRacer". LinuxWorld.com. Archived from the original on October 18, 2000. Retrieved August 8, 2016.

Andrade, G., Ramalho, G., Santana, H., & Corruble, V. Challenge-Sensitive Action Selection: an Application to Game Balancing. *IEEE/WIC/ACM International Conference On Intelligent Agent Technology*. doi: 10.1109/iat.2005.52

Beavis, C., Rowan, L., Dezuanni, M., McGillivray, C., O'Mara, J., Prestridge, S., Stieler-Hunt, C., Thompson, R., & Zagami, J. (2014). Teachers' Beliefs about the Possibilities and Limitations of Digital Games in Classrooms. E-Learning and Digital Media, 11(6), 569–581. https://doi.org/10.2304/elea.2014.11.6.569

Code.org, May 2022. Retrieved from https://code.org/about

Coller, B.D. & Scott, M.J. (2009). Effectiveness of using a video game to teach a course in mechanical engineering. *Computers & Education, 53*(3), 900-912. Elsevier Ltd. Retrieved July 9, 2022 from https://www.learntechlib.org/p/67279/.

Dalheimer, Matthias Kalle; Welsh, Matt. Running Linux (5th ed.). O'Reilly Media. pp. 190–193.

Hainey, T., Connolly, T., Boyle, E., Wilson, A., & Razak, A. (2016). A systematic literature review of games-based learning empirical evidence in primary education. *Computers &Amp; Education*, *102*, 202-223. doi: 10.1016/j.compedu.2016.09.001

Korhonen, H., & Koivisto, E. (2007). Playability heuristics for mobile multi-player games. *Proceedings Of The 2Nd International Conference On Digital Interactive Media In Entertainment And Arts - DIMEA '07*. doi: 10.1145/1306813.1306828

Lastowka, G. (2011). Minecraft as Web 2.0: Amateur Creativity & Digital Games. *SSRN Electronic Journal*. doi: 10.2139/ssrn.1939241

Michael Dezuani and Jo Macri, (2020). "Minecraft: Education Edition for Educational Impact." A Research Report developed for Microsoft by Queensland University of Technology's Digital Media Research Centre.

Minecraft TimeCraft, (2022). Retrieved from https://code.org/minecraft

Morelli, T. (2014). Towards more accurate open source kart race balancing. *2014 IEEE Games Media Entertainment*. doi: 10.1109/gem.2014.7048073

Morelli, T. (2015). Presenting a standard slot machine as an interactive racing game. *2015 IEEE Games Entertainment Media Conference (GEM)*. doi: 10.1109/gem.2015.7377213

National reforms in vocational education and training and adult learning, (2022). Retrieved from https://eacea.ec.europa.eu/national-policies/eurydice/content/national-reforms-vocational-education-and-training-and-adult-learning-27_en

Prensky, M. (2003). Digital game-based learning. *Computers In Entertainment*, *1*(1), 21-21. doi: 10.1145/950566.950596

Professional Learning for Middle and High School Teachers, 2022. Retrieved from https://code.org/educate/professional-learning/middle-high

Rexhepi, A., Filiposka, S., & Trajkovik, V. (2018). Youth e-participation as a pillar of sustainable societies. *Journal Of Cleaner Production*, *174*, 114-122. doi: 10.1016/j.jclepro.2017.10.327

Summary of source data for Code.org infographics and stats, May 2022 https://docs.google.com/document/d/1gySkItxiJn_vwb8HIIKNXqen184mRtzDX12cux0ZgZk/pub

Tian, J., Liu, J., Liang, S., Ning, Y., Li, H., & Zhao, G. (2016). Wireless transmission system for motion sensing game controller based on low power Bluetooth technology. *2016 IEEE 13Th International Conference On Signal Processing (ICSP)*. doi: 10.1109/icsp.2016.7878040

Tijs, T.J.W., Brokken, D., IJsselsteijn, W.A. (2008). Dynamic Game Balancing by Recognizing Affect. In: Markopoulos, P., de Ruyter, B., IJsselsteijn, W., Rowland, D. (eds) Fun and Games. Fun and Games 2008. Lecture Notes in Computer Science, vol 5294. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-88322-7_9

Triantafyllou, S.A. (2023). A Quantitative Research About MOOCs and EdTech Tools for Distance Learning. In: Auer, M.E., El-Seoud, S.A., Karam, O.H. (eds) Artificial Intelligence and Online Engineering. REV 2022. Lecture Notes in Networks and Systems, vol 524. Springer, Cham. https://doi.org/10.1007/978-3-031-17091-1_52

Triantafyllou, S.A. (2022a). Constructivist Learning Environments. Proceedings of The 5th International Conference on Advanced Research in Teaching and Education doi: https://www.doi.org/10.33422/5th.icate.2022.04.10

Triantafyllou, S.A. (2022b). TPACK and Toondoo Digital Storytelling Tool Transform Teaching and Learning. In: Florez, H., Gomez, H. (eds) Applied Informatics. ICAI 2022. Communications in Computer and Information Science, vol 1643. Springer, Cham. https://doi.org/10.1007/978-3-031-19647-8_24

Triantafyllou, S.A. (2022c) "WORK IN PROGRESS: Educational technology and knowledge tracing models," 2022 IEEE World Engineering Education Conference (EDUNINE) pp. 1-4. Available at: https://doi.org/10.1109/edunine53672.2022.9782335

Triantafyllou, S., Georgiadis, C. (2022). Gamification of MOOCs and security awareness in corporate training. In: Proceedings of the 14th International Conference on Computer Supported Education. Available at: https://doi.org/10.5220/0011103000003182

Triantafyllou, S. A. (2021). MOOCs and EdTech Tools for Distance Learning. Proceedings of The 4th World Conference on Future of Education. doi: https://doi.org/10.33422/4th.wcfeducation.2021.12.05

Triantafyllou, S. A. (2019). Digital Revolution, Digital Economy and E-Commerce Transforming Business and Society. The Transition from the Industrial Revolution to the Digital Revolution. GRIN Verlag.

Wu, & Wang, A. I. (2012). A Guideline for Game Development-Based Learning: A Literature Review. International Journal of Computer Games Technology, 2012, 1–20. https://doi.org/10.1155/2012/103710