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RESEARCH ARTICLE

Gamification in preschool science education

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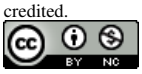

Abstract: Over the last few years, rapid technological progress has developed our lives in all areas. The adoption of technology in the everyday lives of both adults and children through smart mobile devices has led to the foreseeable integration of digital tools in the educational process. Smart mobile devices and the applications that accompany them have been proven effective in the educational field since they allow students to acquire knowledge through activities with an interactive and playful character. A technique that has gained popularity among technology users in the last decades is gamification. Gamification combines mechanisms and elements of games, enhancing students' learning, motivation, and interest in various educational fields, such as mathematics and science. The usage of game elements in education is not encountered for the first time due to the spread of gamification in technology, but it has been mentioned since the early ancient Greek years. However, technology has reinforced gamification through components and techniques that provide students with all the necessary supplies leading to positive learning outcomes. This bibliographic review presents the literature findings on gamification through smart mobile devices in science teaching in preschool education.

Keywords: mobile learning, gamification, science education, natural Sciences, mathematics, preschool education

1 Introduction

Over time, teachers are constantly called to discover new teaching techniques and tools to apply in teaching practice. The ultimate goal of this constant search is to attract their learners' interest and attention. Applying game elements in education has always been a practical approach, as it enhances students' motivation and skills (Kapp, 2012).

The importance of play at an early age is already found in Ancient Greece, where Plato pointed out the importance of play in the education of young children, arguing that play contributes to the formation of tomorrow's citizens and the development of their discipline (Williams, 2010). Aristotle also emphasized the role of play in the cultivation of children's mental functions and especially imagination (Curren, 2000). According to Bruce (1987), play is an integral part of preschool education and is essential for young children's development. The importance of play in learning during preschool age is supported both by the literature (Ali, 2021) and the educational community, with play being an essential part of the preschool education curriculum in Greece (Pechtelidis & Stamou, 2017).

In education, play and learning are directly related, as it is argued that play is an educationally powerful process, where learning is achieved spontaneously, even if an adult is not present (Wood & Bennett, 1997). In particular, play enables children to take on roles and make decisions (Jones, 2000), developing their skills and knowledge (Fromberg, 1999) while enhancing their creative thinking (Bruner, 1972).

What differentiates the educational game from the out-of-school game is the teacher's educational goals when designing the game (Saracho & Spodek, 1994). In addition, games are a different approach to teaching lessons, such as math, as they promote excitement and enjoyment. At the same time, participation (Ernest, 1986) and cooperation (Humphreys & Smith, 1987) are enhanced by creating positive relationships between peers (Hartup, 1993). Also, by applying game elements in education, students can solve problems and perform tasks that require many solutions (Sylva Bruner & Genova, 1976).

In recent years, a technique that has become quite popular and utilizes the elements and mechanisms of games is gamification (Kapp, 2012). Gamification has appeared in recent decades in various fields, such as industry and education (Huotari & Hamari, 2012).

2 Gamification

There are several definitions for gamification in the literature, most of which share some standard features concerning thinking and game mechanisms to solve problems (Zichermann & Cunningham, 2011). Gamification is a process that aims to increase the external and internal motivation of users to engage them in the project through enjoyable activities (Buckle & Doyle, 2016). Internal motivation is the performance of an activity for the user's internal satisfaction, while external motivation is mobilized by acquiring separate amplifiers (Fischer, Malycha & Schafmann, 2019).

Unlike "serious games", which are specially designed games for non-entertainment purposes, gamification incorporates game mechanisms and elements to create engaging and motivating experiences for users (Deterding, Dixon, Khaled & Nacke, 2011). Game elements provide resources, in the form of game objects (3D environments, plot, points, challenges, time pressure, leader boards, self-representation with avatars, etc., see Figure 1) (Deterding et al., 2011) and mechanisms, which are the rules that define how these objects are distributed and handled (Khan et al., 2020). These elements can be used individually or in combination (Razali et al., 2020). Research has shown that players prefer different game elements depending on the individual characteristics of each user, such as gender (Jahn et al., 2021). Users can select and create from the beginning some elements, such as their avatar, which will represent them and interact with the system (Mohamad et al., 2018).

Points, badges and leader boards are three of the most common game rewards elements used in both in-game and off-game settings (Zichermann & Cunningham, 2011). More specifically, points and badges are awarded to users when they answer questions correctly or complete a structured task or other achievements. Next, the leader boards show the players 'scores, while time pressure influences users' decisions and the direction of the game (Rahman et al., 2018).

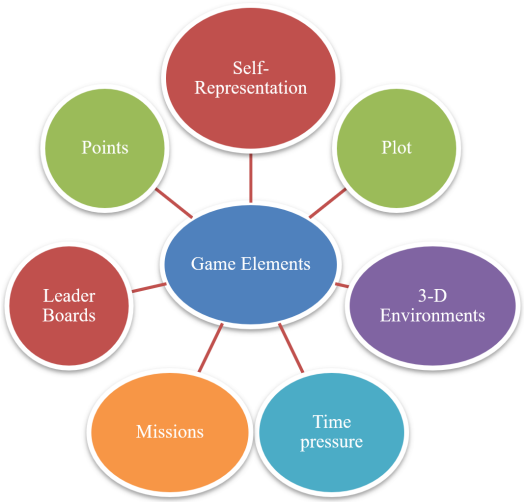

Figure 1 Game elements (Deterding et al.,2011)

Game mechanisms make up the building blocks of a game (Schöbel et al., 2020). They are used to develop a gamified idea, selected and combined to create a pleasurable gaming experience (Blohm & Leimeister, 2013). Such mechanisms can be:

(1) challenges;
(2) competition;
(3) collaboration;
(4) rewards;
(5) feedback, *etc*.

The above data are presented in detail in Table 1.

Table 1 Game mechanisms and their functionality in gamification

Game Mechanics	Functionality
Challenges	Users can test their knowledge by applying it to overcome a challenge.
Competition	The user faces another user to achieve a common goal.
Collaboration	Motivates participants to collaborate to achieve better results.
Rewards	Virtual symbols are used as a reward to signal users' achievements.
Feedback	The measurement is used to inform users of where they stand concerning achieving their goals.

We refer to these mechanisms as critical components because designers selected and used them as the central elements for creating gaming concepts (Schöbel et al., 2020).

Suppose the elements mentioned above are used correctly and appropriately in the educational process, the interest and the attention of the trainees' increases, while simultaneously, the socio-emotional skills of the students are developed (Kapp, 2012). Therefore, applying these elements in education is essential and should be widely applied by teachers (Rahman et al., 2018).

3 Gamification in education

One of the main goals of gamification in education is to gain students' attention and motivate them to engage in learning activities (Deterding et al., 2011; Zichermann & Cunningham, 2011). Gamification uses some basic reinforcement techniques mentioned above: competition and collaboration (Andrade & Law, 2018). Competition is the ability of the user to win, not by preventing his opponent from winning, but by optimizing his performance to achieve the desired goal (Andrade & Law, 2018). In contrast, collaboration refers to working together to achieve mutually pursued goals.

It is important to note that when we talk about gamification in education, we are not talking about games or Game-Based Learning, as its purpose is not fun. It is a differentiated form of learning, which approaches the concept of games by utilizing their mechanisms and elements (Deterding et al., 2011). Gamification aims to motivate the user using external motivations, such as medals and achievements (badges), so that, when it is applied in educational practice, it leads to positive learning outcomes (Kapp, 2012).

Gamification is a helpful tool that encourages students to actively participate in the educational process in various ways (Lamrani et al., 2018). Students learn through experimentation and discovery by the following complex, game-like rules systems (Lee & Hammer, 2011). At the same time, they have the freedom to perform tasks of varying levels of complexity and difficulty. This also implies the freedom to fail, as games allow many problem-solving efforts and provide different paths to achieving goals.

Furthermore, the process of co-designing has proved to be helpful. Teachers and students select and utilize gamification elements on a teaching object in this process. In this way, students have the feeling that they participate in the creation of their learning, and as a result, they involve pleasantly in the learning process, while at the same time, a better relationship develops between them and their teachers (Ramos-Vega et al., 2021). At the same time, teachers succeed in guiding the students, recognizing their efforts, and rewarding them through a system that offers feedback and does not promote failure (Hamari et al., 2014).

Overall, when the above elements are transferred to the learning process, the students' motivations for learning and cognitive involvement are encouraged, leading to the best possible learning (Kapp, 2012; Lee & Hammer, 2011). In some cases, learners' participation in lessons through gamification is greater and more active than their participation in other lessons, and students tend to find these lessons more exciting and engaging than those without gamification (Zsoldos-Marchis, 2020).

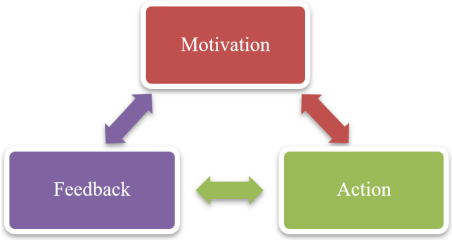

Figure 2 The process of gamification in education

4 Gamification and ICT

Gamification is not always done through specific elements and mechanisms (Huotari & Hamari, 2012). The omnipresence of information and communication technologies and our growing dependence on them have affected our lives in all forms (Surendeleg et al., 2014), and the field of gamification was not an exception. New technologies have strongly influenced educational gamification and appear in various forms, such as applications or video games (Dvoryatkina et al., 2021). The main advantages of utilizing gamification through new technologies are the low development cost and the exciting learning content created by game elements (Surendeleg et al., 2014).

The integration of new technologies in education is not something that is first encountered through gamification. A considerable amount of research has been done to examine smart mobile devices and computers in education, observing positive outcomes for children's learning (Papadakis et al., 2016a). More specifically, over the last decade, the research community (Papadakis & Kalogiannakis, 2019) has shown through various researches that interactive tools, such as smartphones and tablets, offer students a better visualization of the teaching material (Fokides & Zachristou, 2020) functioning as a great complement to traditional teaching methods (Gasparini & Culén, 2011). Students can communicate with each other by asking and answering questions to solve a problem (Skaraki, 2021), while they can still create together using rich digital resources, even outside the classroom (West, 2013). Clark & Luckin (2013) believe that smart mobile devices in the learning process support collaborative learning, providing individualized learning experiences while enhancing universal education.

The massive variety of devices from which a teacher has to choose raises the question of whether and to what extent all of these devices are effective in the educational process (Davis et al., 2017). Studies have shown that desktop or laptop computers improve students' stimulation and autonomy (Iskrenovic-Momcilovic, 2018). As mentioned above, similar results have been recorded from smart mobile devices in research conducted in education. Although both of the teaching approaches have great results in the learning process, it is considered that tablets are more effective in comparison to computers. This might be down to the ease of use via the finger, or the size of the tablet's screen (Davis et al., 2017), elements that lead to the more active role children have when using these devices (Papadakis et al., 2021). Moreover, tablets are lightweight, portable, have wireless internet access, and their cost is lower than computers' cost (Major et al., 2017).

Regarding the integration of smart mobile devices in preschool education, several studies have highlighted the advantages these devices provide to preschool children (Papadakis et al., 2021). More specifically, during an activity using a smart mobile device, children communicate with each other, discussing each time who will have access to the device and co-deciding on their actions, in order to be able to complete a task or an activity, sharing feelings of joy and enjoyment (Fantozzi, 2021). Combining mobile devices with appropriate educational applications promotes learning in a pleasant environment (Skaraki, 2021). In this way, children interact successfully with the learning object while developing listening, collaboration and autonomy (Furman et al., 2019).

At the same time, the learning of various learning objects, such as mathematics, is enhanced through the didactic use of smart mobile devices (Zaranis et al., 2013). Many researchers have found that the interactive environment created in kindergarten by using tablets attracts children's interest, encouraging them to participate more closely and effectively in mathematical activities (Papadakis et al., 2018).

Teachers use technology in various forms in education depending on their educational program and goals (Ramsey, 2018). Gamification through smart mobile devices in education has been proved to be a successful learning approach because of its positive impacts on students' enjoyment and motivation (Metwally et al., 2021). However, not only students but also teachers benefit from the gamification process. In contradistinction to designing complicated games, which require a large amount of money or time (Dicheva et al., 2015), gamification uses game elements to existing systems (Sanmugam et al., 2015) through various software forms, such as apps or simulation games (Peixoto & Silva, 2017).

Teachers need to choose their gamified content carefully, as in this way, technology can be used effectively in education. One of the main goals of teachers who utilize the digital tools of gamification in educational practice is to attract the interest of their students. Teachers need to pay attention to every detail in a gamified app to make this possible, starting from its mechanism. The mechanism of an app is fundamental, as it includes the rules of a game, the algorithms and what the player does (Putra & Yasin, 2021).

Gamification can be implemented through smart mobile devices, such as puzzles, strategy games or simulation (Zakaria et al., 2020). Sudarmilah & Arbain (2019), using video games, concluded that gamification has positive results in the cognitive ability of preschool children. At the same time, Matchacheep, Chookeaw & Nilsuk (2019) showed that digital storytelling through gamification positively affects children's learning and teamwork skills.

The effectiveness of gamification in preschool education is found in many studies in the literature, such as that of Parra-González et al. (2021), in which scholars compared the application of gamification and flipped classrooms on the subject of Physical Education in kindergartens in Spain and found that gamification achieved better results in the autonomy of preschool children. Furthermore, applications of gamification, which have been made in educational practice, have shown that students' attention is improved (Setiawan & Soeharto, 2020), while the enthusiasm and interaction between learners are increased (Umboh et al., 2021).

In addition, the various difficulty levels offered through the gamified apps provide opportunities for all students regardless of their learning level (Bovermann & Bastiaens, 2020). The score can be adjusted depending on the purpose of the game being created. In general, the game's purpose and direction are influenced by the predetermined learning goals that the teacher will set during the design (Putra & Yasin, 2021). These can be achieved through interactive tools, such as Microsoft Office embedded tools, which do not require programming skills (Bovermann & Bastiaens, 2020).

5 Gamification in preschool science education

The issue of critical teaching-learning science subjects, such as mathematics and natural sciences, often tend to be characterized by students as tricky, difficult to understand or too bored (Setiawa & Soeharto, 2020). For this reason, teachers are looking for ways to motivate their students by teaching the lessons in a fun way.

Teaching science subjects is extremely important in preschool, where children's curiosity about exploring the world around them can be nurtured and lay the foundation for their later learning in these areas (National Science Teachers Association, 2014; Fragkiadaki & Ravanis, 2021). Preschoolers develop positive attitudes toward science (Gomes & Fleer, 2019), by learning about specific scientific concepts (Akerson et al., 2015) and by understanding the world around them (Larimore, 2020). At the same time, they develop their vocabulary with scientific terms (Eshach & Fried, 2005). In particular, activities where students are asked to describe phenomena (Fragkiadaki & Ravanis, 2021), explain their ideas and seek information in informative texts (Guo et al., 2016) support their language development and literacy.

Therefore, educators need to look for ways to encourage preschoolers to develop their scientific thinking and their emerging science concepts (Bose & Seetso, 2016) while working in the light of a holistic approach, as physical, socio-emotional and cognitive development are priorities in preschool education (Schwarz et al., 2017). More generally, preschool education's influences from Piaget's constructivist theory and Vygotsky's theory of cognitive development emphasize the importance of social interactions and external stimuli in preschool (Copple & Bredekamp, 2009).

As argued by many researchers (Nayfeld et al., 2013; Kalogiannakis et al., 2018), sciences support the socio-emotional development of preschool children. More specifically, through collaborative learning (Ampartzaki & Kalogiannakis, 2016), students organize research and solve problems, and as a result, they are enhancing their executive function. On the other hand, teachers can enhance students' learning by following various educational practices, such as linking to children's pre-existing knowledge about the phenomena they are examining or highlighting events during the observation of a phenomenon (Andersson & Gullberg, 2014).

Regarding teaching subjects from the field of Natural Sciences, preschool children develop respect for the natural environment through opportunities to explore natural phenomena (Larimore, 2020). However, many educators express difficulties in teaching Natural Sciences, as it is a field of science that needs an exceptional conceptual understanding. In educational reality, kindergarten teachers spend less time teaching Natural Sciences than any other field (Edwards, 2011). This lack of time may be due to teachers' lack of knowledge or interest (Garbett, 2003) in teaching Natural Sciences. As a result, preschoolers lose meaningful experiences with sciences and gain knowledge gaps (Larimore, 2020). It is no coincidence that although preschoolers' performance at the beginning of the school year is similar in Mathematics, Natural Sciences and Literacy, at the end of the school year, it falls markedly lower (Greenfield et al., 2009). Therefore, it is essential to offer open-ended experiences to preschool students, including content and practices from science (National Science Teachers Association, 2014).

In combination with the materials provided to learners, the environment in which learning takes place is critical (Fleer et al., 2014). In particular, digital tools, such as smart mobile devices, give students different learning styles (Kalogiannakis et al., 2018) and different skills (Sezgin et al., 2018) to participate in the educational process. Regarding the integration of smart mobile devices in the teaching of Natural Sciences, it has been proven that these devices offer students a better visualization of phenomena related to the Natural Sciences and make it easier for them to understand better these concepts (Fokides & Zachristou, 2020).

Combined with the game elements and mechanisms, which gamification utilizes, if used in the right way, can increase the students' enjoyment and achievements (Morris et al., 2013). Students are encouraged to try new things and repeat the exercises if they wish, minimizing the fear of failure. Adapting data, which motivate preschoolers to try again (Hunter & Werbach, 2012), enhance the willingness to participate in the process. In addition, the capability to correct a mistake involves students in a typical assessment process (Sánchez-Rivas et al., 2019).

Thus, preschool children can enter the role of scientists, experiment, and participate in learning through discovery (Tsai, 2018). Consequently, positive results are provided in motivation, commitment and social interaction (Kalogiannakis et al., 2021). However, in order to achieve the above, the role of the teacher is essential, as he/she is the one who plans the educational practice, evaluates the type of each student, chooses the materials, the pedagogical strategies and how students will receive feedback (Zourmpakis et al., 2022).

Preschool education lays the foundation for children's future attitudes and perceptions around sciences. Children develop relationships between the real world, mathematical concepts and symbols (Gray et al., 2000). Learning mathematical concepts in preschool should involve children creatively, allowing them to learn problem-solving strategies (Seo & Ginsburg, 2004) through formal and informal learning processes (Gasteiger & Benz, 2018). Preschoolers can develop their math skills through daily activities, such as playing or cooking (Anthony & Walshaw, 2009). Similar results are provided by daily interaction with information and communication technologies and smart mobile devices (Papadakis et al., 2016a).

Several researchers have studied and documented the positive effects of smart mobile devices in teaching mathematical concepts in preschool education (Papadakis et al., 2016a; Papadakis et al., 2021; Outhwaite et al., 2019). The interaction of preschool children with interactive applications, which incorporate mathematical concepts into play-like activities (Hirsh-Pasek et al., 2015), enhances their participation (Papadakis et al., 2016b). In addition, the use of game elements in teaching mathematics is one of the methods that can help students learn mathematics with pleasure. Students find lessons through gamification more exciting and more active in their activities (Zsoldos-Marchis, 2020).

Examples of the application of gamification for the development of students' mathematical skills in preschool education have shown that the gamification elements promote learning through experimentation, exploration, mistakes, comprehension and repetition (Lamrani & Abdelwahed, 2020). What is essential to consider when designing mathematical activities for preschoolers is that children of this age understand problems that refer to real-world situations (Papadakis et al., 2021). While in a gamification environment, preschool children are led to learning through a fun process and at the same time, their active participation is encouraged, resulting in the successful acquisition of basic mathematical concepts (Karademir & Akman, 2021). In addition, the level of children's autonomous learning increases along with their interest in completing math tasks (Mowafi et al., 2019). Thus, every student gains emotional, cognitive and social benefits from the process of gamification (Karamert & Vardar, 2021).

However, there are some difficulties in the practical application of game elements and mechanisms when teaching mathematics, such as the extra time that the teacher should devote, the work for the educational mathematical content of the application and the careful selection of software (Bocconi et al., 2018). Considering the above- mentioned, several scholars using multimedia elements, such as text, images, sound, and animation, have created and implemented their interactive games, recording positive results in cultivating students' mathematical ability (Udjaja et al., 2018).

In addition, various mobile applications, which are based on gamification features, such as formative assessment and feedback, have been tested by the research community, suggesting that students' motivation and commitment can be enhanced while improving the learning process, even when students do not receive feedback from their teacher. However, they receive performance feedback directly from the system (Kickmeier-Rust et al., 2014).

Properly designing a digital application and adapting it to appropriate educational scenarios can introduce preschoolers to concepts long ago considered problematic for their age (Zaranis et al., 2013). From this point of view, it can be considered that gamification can contribute to understanding scientific concepts from chemistry at the preschool level. Although they show difficulties expressing scientific words and expressions, preschoolers can perceive mechanical processes from chemistry (Adbo & Carulla, 2019).

Similarly, students' participation in mobile applications and gamification promotes their biology knowledge. In some cases, researchers select competitive gamified apps, such as the "Kahoot" application, to emphasize students' commitment and motivation in the learning process of objects characterized as tricky, such as Biology (Jones et al., 2019). In this way, students expand their knowledge on health topics and begin adopting choices for a healthier lifestyle (Kostenius et al., 2018).

6 Limitations – Prospects for future research

There are some limitations considering gamification in education that should be addressed in this paper. Therefore, it is essential to look at some criticisms that have been formulated in the

past few years. As highlighted in various studies, game elements frequently repeated in different settings, such as rewards and scoreboards, can interfere with students' intrinsic motivations (Perryer et al., 2016), paving the way for competition (Hamari et al., 2014).

Creating a competitive environment is controversial, and it is commonly used in science education to combat students' negative emotions and experiences and increase learning outcomes (Kalogiannakis et al., 2021). Therefore, competition can be considered part of gamification and might cause social pressure to increase students' involvement in the learning process (Sailer & Homner, 2020).

On the other hand, as argued in several studies, a gamification element, which positively affects one person's performance, may not improve or may even worsen another person's performance and motivation (Garcia-Iruela & Hijón-Neira, 2020), or it may even worsen the performance for the whole group (Marlow et al., 2016). This is where adaptive gamification comes in to help overcome the many limitations and related difficulties in "conventional" gamification (Zourmpakis et al., 2022).

In addition, it is argued that it is common for students to be discriminated against based on their skill levels and grades, which they achieve during gamification activities. This can lead to a gradual loss of motivation and commitment of participants (Toda et al., 2017). At the same time, loss of productivity can be detected when game elements distract users from the activity's primary purpose (Thiebes et al., 2014).

These challenges, which refer to creating a competitive environment through gamification in education, arise from the lack of appropriate methods and/or frameworks for the design and development of gamification in the context of learning and should be taken seriously by teachers when applying gamification in their classrooms. To avoid such problems and limitations, teachers should be careful when designing gamification teaching tools and take into account the needs of their students and their educational goals. In this way, gamification can enhance educational processes in science teaching in preschool, with promising results regarding students' motivations.

Furthermore, teachers find it challenging to accept gamified environments, as they consider that they are not directly related to the content of their lessons (Markopoulos et al., 2015). Therefore, research findings on gamification in science teaching in preschool are limited. Our next steps in advancing these findings are to study, in the context of experimental research, how we can use gamification to teach science in different levels of formal education, depending on the needs of the students. In this way, it will also be explored whether the well-designed application of gamification in science teaching in preschool enhances preschool students' motivation and thinking skills and whether and to what extent it enhances competition among preschool children.

7 Conclusions

A present literature review is an initial approach to the issue of utilizing gamification for the teaching of science subjects in preschool education. The literature review findings gave us information about the term of gamification in general and the forms in which we encounter it in various fields and, more specifically, in education.

The gamification elements and strategies were presented and their application by utilizing new technologies and smart mobile devices. In education, gamification positively affects the learning process and positively affects teaching subjects from science. Students are more confident to participate in the learning process, while the collaboration between peers is enhanced, creating appropriate fields for the implementation of collaborative learning. In addition, the feedback it provides can give teachers direct information about the learning level of their students.

The importance of play in preschool is emphasized from the beginning of the study. When play's pedagogical strategies and elements are used in preschool education, preschool children become actively involved in learning and acquire knowledge through exploration and discovery. The present study aimed to describe the situation of gamification in preschool science education dominating the literature and the possibilities for teaching these subjects. However, the findings present some problems that future research should consider. In addition, limited studies have been conducted on the application of gamification in preschool science education, and as a result, we do not have a collective picture of the issue and the impact that gamification has on preschool education.

Therefore, more research is needed to study this subject, considering the limitations and problems mentioned, such as the mechanisms and elements used in conjunction with the learning strategies. Also, one of the most significant issues of gamification in education should be considered, which is the creation of competition between students and the elimination

of internal motivations. Future studies will help to clarify the actual effects on learners' motivations. Finally, it is essential to consider the application of gamification to learning objects underrepresented by the research community in preschool education, such as Chemistry and Biology.

Conflicts of interest

The author declares that they have no conflict of interest.

References

Adbo, K., & Carulla, C. V. (2019). Designing play-based learning chemistry activities in the preschool environment. Chemistry Education Research and Practice, 20(3), 542-553. https://doi.org/10.1039/C8RP00306H

Akerson, V. L., Weiland, I., & Fouad, K. E. (2015). Children's ideas about life science concepts. In Research in early childhood science education (pp. 99-123). Springer, Dordrecht. https://doi.org/10.1007/978-94-017-9505-0_5

Ampartzaki, M., & Kalogiannakis, M. (2016). Astronomy in early childhood education: A concept-based approach. Early Childhood Education Journal, 44(2), 169-179. https://doi.org/10.1007/s10643-015-0706-5

Andersson, K., & Gullberg, A. (2014). What is science in preschool, and what do teachers have to know to empower children?. Cultural studies of science education, 9(2), 275-296. https://doi.org/10.1007/s11422-012-9439-6

Andrade, P., & Law, E. L. C. (2018). User-based evaluation of gamification elements in an educational application. In Proceedings of the 32nd International BCS Human-Computer Interaction Conference 32 (pp. 1-13). https://doi.org/10.14236/ewic/HCI2018.27

Anthony, G., & Walshaw, M. (2009). Mathematics education in the early years: Building bridges. Contemporary Issues in Early Childhood, 10(2), 107-121. https://doi.org/10.2304/ciec.2009.10.2.107

Blohm, I., & Leimeister, J. M. (2013). Gamification. Business & information systems engineering, 5(4), 275-278. https://doi.org/10.1007/s12599-013-0273-5

Bocconi, S., Chioccariello, A., & Earp, J. (2018). The Nordic approach to introducing Computational Thinking and programming in compulsory education. Report prepared for the Nordic@ BETT2018 Steering Group, 397-400.

Bose, K., & Seetso, G. (2016). Science and mathematics teaching through local games in preschools of Botswana. South African Journal of Childhood Education, 6(2), 1-9. https://doi.org/10.4102/sajce.v6i2.453

Bovermann, K., & Bastiaens, T. J. (2020). Towards a motivational design? Connecting gamification user types and online learning activities. Research and Practice in Technology Enhanced Learning, 15(1), 1-18. https://doi.org/10.1186/s41039-019-0121-4

Bruner, J. S. (1972). Nature and uses of immaturity. American psychologist, 27(8), 687. https://doi.org/10.1037/h0033144

Bryant, D., Clifford, D., Early, D., & Little, L. (2005). NCEDL Pre-Kindergarten Study. Early Developments. Volume 9, Number 1, Spring 2005. FPG Child Development Institute, University of North Carolina.

Buckley, P., & Doyle, E. (2016). Gamification and student motivation. Interactive learning environments, 24(6), 1162-1175. https://doi.org/10.1080/10494820.2014.964263

Clark, W. & Luckin, R. (2013). What the research says: iPads in the classroom. London Knowledge Lab Report. Retrieved from http://digitallearningteam.org/

Copley, J. V., & Padron, Y. (1998). Preparing Teachers of Young Learners: Professional Development of Early Childhood Teachers in Mathematics and Science.

Copple, C., & Bredekamp, S. (2009). Developmentally appropriate practice in early childhood programs serving children from birth through age 8. National Association for the Education of Young Children. 1313 L Street NW Suite 500, Washington, DC 22205-4101.

Curren, R. R. (2000). Aristotle on the necessity of public education. Rowman & Littlefield Publishers.

Davis, L. L., Kong, X., McBride, Y., & Morrison, K. M. (2017). Device comparability of tablets and computers for assessment purposes. Applied Measurement in Education, 30(1), 16-26. https://doi.org/10.1080/08957347.2016.1243538

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011, September). From game design elements to gamefulness: defining "gamification". Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments (pp. 9-15). https://doi.org/10.1145/2181037.2181040

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. Journal of educational technology & society, 18(3), 75-88.

Edwards, K. (2011). Learning scientific knowledge from and with others. Early Childhood Folio, 15(1), 7-11.
https://doi.org/10.18296/ecf.0159

Ernest, P. (1986). Games. A rationale for their use in the teaching of mathematics in school. Mathematics in school, 15(1), 2-5.
https://doi.org/10.1093/teamat/5.3.97

Eshach, H., & Fried, M. N. (2005). Should science be taught in early childhood? Journal of science education and technology, 14(3), 315-336.
https://doi.org/10.1007/s10956-005-7198-9

Fantozzi, V. B. (2021). "It's Everyone's iPad": Tablet use in a play-based preschool classroom. Journal of Early Childhood Research, 19(2), 115-127.
https://doi.org/10.1177/1476718X20983835

Fischer, C., Malycha, C. P., & Schafmann, E. (2019). The influence of intrinsic motivation and synergistic extrinsic motivators on creativity and innovation. Frontiers in psychology, 10, 137.
https://doi.org/10.3389/fpsyg.2019.00137

Fleer, M., Gomes, J., & March, S. (2014). Science learning affordances in preschool environments. Australasian Journal of Early Childhood, 39(1), 38-48.
https://doi.org/10.1177/183693911403900106

Fragkiadaki, G., & Ravanis, K. (2021). The unity between intellect, affect, and action in a child's learning and development in science. Learning, Culture and Social Interaction, 29, 100495.
https://doi.org/10.1016/j.lcsi.2021.100495

Fokides, E., & Zachristou, D. (2020). Teaching Natural Sciences to Kindergarten Students Using Tablets: Results from a Pilot Project. Mobile learning applications in early childhood education (pp. 40-60). IGI Global.
https://doi.org/10.4018/978-1-7998-1486-3.ch003

Fromberg, D. P. (1999). A review of research on play. The early childhood curriculum: Current findings in theory and practice, 27-53.

Furman, M., De Angelis, S., Dominguez Prost, E., & Taylor, I. (2019). Tablets as an educational tool for enhancing preschool science. International Journal of Early Years Education, 27(1), 6-19.
https://doi.org/10.1080/09669760.2018.1439368

Garbett, D. (2003). Science education in early childhood teacher education: Putting forward a case to enhance student teachers' confidence and competence. Research in science education, 33(4), 467-481.
https://doi.org/10.1023/B:RISE.0000005251.20085.62

Garcia-Iruela, M., & Hijón-Neira, R. (2020). What Perception Do Students Have About the Gamification Elements?. IEEE Access, 8, 134386-134392.
https://doi.org/10.1109/ACCESS.2020.3011222

Gasparini, A., & Culén, A. L. (2011). Childrens Journey with iPads in the Classroom. In Opportunities and Challenges when Designing and Developing with Kids@ School at the Interaction Design for Children Conference (IDC 2011), Ann Arbor, Michigan.

Gasteiger, H., & Benz, C. (2018). Enhancing and analyzing kindergarten teachers' professional knowledge for early mathematics education. The Journal of Mathematical Behavior, 51, 109-117.
https://doi.org/10.1016/j.jmathb.2018.01.002

Gomes, J., & Fleer, M. (2019). The development of a scientific motive: How preschool Science and home play reciprocally contribute to Science learning. Research in Science Education, 49(2), 613-634.
https://doi.org/10.1007/s11165-017-9631-5

Gray, E., Pitta, D., & Tall, D. (2000). Objects, actions, and images: A perspective on early number development. The Journal of Mathematical Behavior, 18(4), 401-413.
https://doi.org/10.1016/S0732-3123(00)00025-0

Greenfield, D. B., Jirout, J., Dominguez, X., Greenberg, A., Maier, M., & Fuccillo, J. (2009). Science in the preschool classroom: A programmatic research agenda to improve science readiness. Early Education and Development, 20(2), 238-264.
https://doi.org/10.1080/10409280802595441

Guo, Y., Wang, S., Hall, A. H., Breit-Smith, A., & Busch, J. (2016). The effects of science instruction on young children's vocabulary learning: A research synthesis. Early Childhood Education Journal, 44(4), 359-367.
https://doi.org/10.1007/s10643-015-0721-6

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work?–a literature review of empirical studies on gamification. In 2014 47th Hawaii international conference on system sciences (pp. 3025-3034). Ieee.
https://doi.org/10.1109/HICSS.2014.377

Hartup, W. W. (1993). Adolescents and their friends. New directions for child and adolescent development, 1993(60), 3-22.
https://doi.org/10.1002/cd.23219936003

Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in "educational" apps: Lessons from the science of learning. Psychological Science in the Public Interest, 16(1), 3-34.
https://doi.org/10.1177/1529100615569721

Humphreys, A. P., & Smith, P. K. (1987). Rough and tumble, friendship, and dominance in schoolchildren: Evidence for continuity and change with age. Child development, 201-212.
https://doi.org/10.2307/1130302

Hunter, D., & Werbach, K. (2012). For the win (Vol. 2). Wharton digital press. https://vr-entertain.com/wpcontent/uploads/BattleHuntersIM_4-US-V1

Huotari, K., & Hamari, J. (2012). Defining gamification: a service marketing perspective. Proceeding of the 16th international academic MindTrek conference (pp. 17-22). https://doi.org/10.1145/2393132.2393137

Iskrenovic-Momcilovic, O. (2018). Using computers in teaching in higher education. Mediterranean Journal of Social Sciences, 9(4), 71. https://doi.org/10.2478/mjss-2018-0116

Jack, C., & Higgins, S. (2019). What is educational technology and how is it being used to support teaching and learning in the early years? International Journal of Early Years Education, 27(3), 222-237. https://doi.org/10.1080/09669760.2018.1504754

Jahn, K., Kordyaka, B., Machulska, A., Eiler, T. J., Gruenewald, A., Klucken, T., ... & Niehaves, B. (2021). Individualized gamification elements: The impact of avatar and feedback design on reuse intention. Computers in Human Behavior, 119, 106702. https://doi.org/10.1016/j.chb.2021.106702

Jones, A. J. (2000). Game theory: Mathematical models of conflict. Elsevier. https://doi.org/10.1533/9780857099693

Jones, S. M., Katyal, P., Xie, X., Nicolas, M. P., Leung, E. M., Noland, D. M., & Montclare, J. K. (2019). A 'KAHOOT!' approach: the effectiveness of game-based learning for an advanced placement biology class. Simulation & Gaming, 50(6), 832-847. https://doi.org/10.1177/1046878119882048

Kalogiannakis, M., Nirgianaki, G. M., & Papadakis, S. (2018). Teaching magnetism to preschool children: The effectiveness of picture story reading. Early Childhood Education Journal, 46(5), 535-546. https://doi.org/10.1007/s10643-017-0884-4

Kalogiannakis, M., Ampartzaki, M., Papadakis, St., & Skaraki, E. (2018). Teaching Natural Science Concepts to Young Children with Mobile Devices and Hands-on Activities. A Case Study. International Journal of Teaching and Case Studies, 9(2), 171-183. https://doi.org/10.1504/IJTCS.2018.090965

Kalogiannakis, M., Papadakis, S., & Zourmpakis, A. I. (2021). Gamification in science education. A systematic review of the literature. Education Sciences, 11(1), 22. https://doi.org/10.3390/educsci11010022

Kapp, K. M. (2012). The gamification of learning and instruction: game-based methods and strategies for training and education. John Wiley & Sons. https://doi.org/10.1145/2207270.2211316

Karademir, A., & Akman, B. (2021). Preschool Inquiry-Based Mathematics in Practice: Perspectives of Teachers and Parents. Eğitimde Nitel Araştırmalar Dergisi, 9(1), 151-178. https://doi.org/10.14689/enad.25.7

Khan, A., Boroomand, F., Webster, J., & Minocher, X. (2020). From Elements to Structures: An Agenda for Organisational Gamification. European Journal of Information Systems, 29(6), 621-640. https://doi.org/10.1080/0960085X.2020.1780963

Kickmeier-Rust, M. D., Hillemann, E. C., & Albert, D. (2014). Gamification and smart feedback: Experiences with a primary school level math app. International Journal of Game-Based Learning (IJGBL), 4(3), 35-46. https://doi.org/10.4018/ijgbl.2014070104

Kostenius, C., Hallberg, J., & Lindqvist, A. K. (2018). Gamification of health education: Schoolchildren's participation in the development of a serious game to promote health and learning. Health Education. https://doi.org/10.1108/HE-10-2017-0055

Lamrani, R., & Abdelwahed, E. H. (2020). Game-based learning and gamification to improve skills in early years education. Computer Science and Information Systems, 17(1), 339-356. https://doi.org/10.2298/CSIS190511043L

Lamrani, R., Chraibi, S., Qassimi, S., & Hafidi, M. (2018). Gamification and serious games based learning for early childhood in rural areas. In International conference on model and data engineering (pp. 79-90). Springer, Cham. https://doi.org/10.1007/978-3-030-02852-7_7

Larimore, R. A. (2020). Preschool science education: A vision for the future. Early Childhood Education Journal, 48(6), 703-714. https://doi.org/10.1007/s10643-020-01033-9

Lee, J. J., & Hammer, J. (2011). Gamifcation in education: What, how, why bother? Academic Exchange Quarterly, 15(2), 1-5.

Lo, C. K., & Hew, K. F. (2020). A comparison of flipped learning with gamification, traditional learning, and online independent study: the effects on students' mathematics achievement and cognitive engagement. Interactive Learning Environments, 28(4), 464-481. https://doi.org/10.1080/10494820.2018.1541910

Loganathan, P., Talib, C., Thoe, N., Aliyu, F., & Zawadski, R. (2019). Implementing Technology Infused Gamification in Science Classroom: A Systematic Review and Suggestions for Future Research. Learn. Sci. Math, 14, 60-73.

López-Belmonte, J., Segura-Robles, A., Moreno-Guerrero, A. J., & Parra-González, M. E. (2021). Projection of e-learning in higher education: a study of its scientific production in web of science. European Journal of Investigation in Health, Psychology and Education, 11(1), 20-32. https://doi.org/10.3390/ejihpe11010003

Major, L., Haßler, B., & Hennessy, S. (2017). Tablet use in schools: impact, affordances and considerations. In Handbook on digital learning for K-12 schools (pp. 115-128). Springer, Cham. https://doi.org/10.1007/978-3-319-33808-8_8

Markopoulos, A. P., Fragkou, A., Kasidiaris, P. D., & Davim, J. P. (2015). Gamification in engineering education and professional training. International Journal of Mechanical Engineering Education, 43(2), 118-131. https://doi.org/10.1177/0306419015591324

Marlow, S. L., Salas, E., Landon, L. B., & Presnell, B. (2016). Eliciting teamwork with game attributes: A systematic review and research agenda. Computers in Human Behavior, 55, 413-423. https://doi.org/10.1016/j.chb.2015.09.028

Matchacheep, S., Chookeaw, S., & Nilsuk, P. (2019, October). A Gamification Digital Storytelling Learning Based on Cooperative Social Cloud to Promote Students' Teamwork Skill in Primary School. In Proceedings of The 3rd International Conference on Digital Technology in Education (pp. 132-135). https://doi.org/10.1145/3369199.3369211

Metwally, A. H. S., Nacke, L. E., Chang, M., Wang, Y., & Yousef, A. M. F. (2021). Revealing the hotspots of educational gamification: An umbrella review. International Journal of Educational Research, 109, 101832. https://doi.org/10.1016/j.ijer.2021.101832

Mohamad, S. N. M., Sazali, N. S. S., & Salleh, M. A. M. (2018). Gamification approach in education to increase learning engagement. Int. J. Humanit. Arts Soc. Sci, 4(1), 22-32. https://doi.org/10.20469/ijhss.4.10003-1

Morris, B., Croker, S., Zimmerman, C., Gill, D., & Romig, C. (2013). Gaming science: the "Gamification" of scientific thinking. Frontiers in psychology, 4, 607. https://doi.org/10.3389/fpsyg.2013.00607

Mowafi, Y., Abumuhfouz, I., & Redifer, J. (2019). A play-based interactive learning approach for fostering counting and numbers learning skills for early childhood education using QR codes mobile technologies. In International Conference on Mobile Web and Intelligent Information Systems (pp. 16-26). Springer, Cham. https://doi.org/10.1007/978-3-030-27192-3_2

National Science Teachers Association. (2014). NSTA position statement: Early childhood science education. Science and Children, 51(7), 10-12.

Nayfeld, I., Fuccillo, J., & Greenfield, D. B. (2013). Executive functions in early learning: Extending the relationship between executive functions and school readiness to science. Learning and Individual Differences, 26, 81-88. https://doi.org/10.1016/j.lindif.2013.04.011

Outhwaite, L. A., Faulder, M., Gulliford, A., & Pitchford, N. J. (2019). Raising early achievement in math with interactive apps: A randomized control trial. Journal of educational psychology, 111(2), 284. https://doi.org/10.1037/edu0000286

Papadakis, S., & Kalogiannakis, M. (Eds.). (2019). Mobile learning applications in early childhood education. IGI Global. https://doi.org/10.4018/978-1-7998-1486-3

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2016a). Comparing tablets and PCs in teaching mathematics: An attempt to improve mathematics competence in early childhood education. Preschool and Primary Education, 4(2), 241-253. https://doi.org/10.12681/ppej.8779

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2016b). Developing fundamental programming concepts and computational thinking with ScratchJr in preschool education: a case study. International Journal of Mobile Learning and Organisation, 10(3), 187-202. https://doi.org/10.1504/IJMLO.2016.077867

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2018). Educational apps from the Android Google Play for Greek preschoolers: A systematic review. Computers & Education, 116, 139-160. https://doi.org/10.1016/j.compedu.2017.09.007

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2021). Teaching mathematics with mobile devices and the Realistic Mathematical Education (RME) approach in kindergarten. Advances in Mobile Learning Educational Research, 1(1), 5-18. https://doi.org/10.25082/AMLER.2021.01.002

Pechtelidis, Y., & G Stamou, A. (2017). The "competent child" in times of crisis: A synthesis of Foucauldian with critical discourse analysis in Greek preschool curricula. Palgrave Communications, 3(1), 1-11. https://doi.org/10.1057/palcomms.2017.65

Peixoto, M., & Silva, C. (2017). A gamification requirements catalog for educational software: results from a systematic literature review and a survey with experts. In Proceedings of the Symposium on Applied Computing (pp. 1108-1113). https://doi.org/10.1145/3019612.3019752

Perryer, C., Celestine, N. A., Scott-Ladd, B., & Leighton, C. (2016). Enhancing workplace motivation through gamification: Transferrable lessons from pedagogy. The International Journal of Management Education, 14(3), 327-335. https://doi.org/10.1016/j.ijme.2016.07.001

Plowman, L., & Stephen, C. (2005). Children, play, and computers in preschool education. British journal of educational technology, 36(2), 145-157. https://doi.org/10.1111/j.1467-8535.2005.00449.x

Putra, S. D., & Yasin, V. (2021). MDA Framework Approach for Gamification-Based Elementary Mathematics Learning Design. International Journal of Engineering, Science and Information Technology, 1(3), 35-39. https://doi.org/10.52088/ijesty.v1i3.83

Rahman, M. H. A., Ismail, D., Noor, A. Z. B. M., & Salleh, N. S. B. M. (2018). Gamification elements and their impacts on teaching and learning-A review. The International Journal of Multimedia & Its Applications (IJMA) Vol, 10. https://doi.org/10.5121/ijma.2018.10604

Ramos-Vega, M. C., Palma-Morales, V. M., Pérez-Marín, D., & Moguerza, J. M. (2021). Stimulating children's engagement with an educational serious videogame using Lean UX co-design. Entertainment Computing, 38, 100405. https://doi.org/10.1016/j.entcom.2021.100405

Ramsey, L. C. (2018). A qualitative study: Perception of preschool teachers use of technology in preparing for school readiness (Doctoral dissertation, Northcentral University).

Razali, N., Nasir, N. A., Ismail, M. E., Sari, N. M., & Salleh, K. M. (2020). Gamification elements in Quizizz applications: Evaluating the impact on intrinsic and extrinsic student's motivation. In IOP Conference Series: Materials Science and Engineering (Vol. 917, No. 1, p. 012024). IOP Publishing. https://doi.org/10.1088/1757-899X/917/1/012024

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. Educational Psychology Review, 32(1), 77-112. https://doi.org/10.1007/s10648-019-09498-w

Sánchez-Rivas, E., Ruiz-Palmero, J., & Sánchez-Rodríguez, J. (2019). Gamification of Assessments in the Natural Sciences Subject in Primary Education. Educational Sciences: Theory and Practice, 19(1), 95-111.

Sanmugam, M., Mohd Zaid, N., Mohamed, H., Abdullah, Z., Aris, B., & Md Suhadi, S. (2015). Gamification as an educational technology tool in engaging and motivating students; An analyses review. Advanced Science Letters, 21(10), 3337-3341. https://doi.org/10.1166/asl.2015.6489

Saracho, O. N., & Spodek, B. (1994). Matching preschool children's and teachers' cognitive styles. Perceptual and motor skills, 78(2), 683-689. https://doi.org/10.2466/pms.1994.78.2.683

Schöbel, S. M., Janson, A., & Söllner, M. (2020). Capturing the complexity of gamification elements: a holistic approach for analyzing existing and deriving novel gamification designs. European Journal of Information Systems, 29(6), 641-668. https://doi.org/10.1080/0960085X.2020.1796531

Schwarz, C. V., Passmore, C., & Reiser, B. J. (2017). Moving beyond "knowing about" science to making sense of the world. Helping students make sense of the world using next generation science and engineering practices, 3-21.

Seo, K. H., & Ginsburg, H. P. (2004). What is developmentally appropriate in early childhood mathematics education? Lessons from new research. Engaging young children in mathematics: Standards for early childhood mathematics education, 91-104.

Setiawan, A., & Soeharto, S. (2020). Kahoot-based learning game to improve mathematics learning motivation of elementary school students. Al-Jabar: Jurnal Pendidikan Matematika, 11(1), 39-48. https://doi.org/10.24042/ajpm.v11i1.5833

Sezgin, S., Bozkurt, A., YILMAZ, E. A., Van der Linden, N., & Learning, P. (2020). Gamification, education and theoretical approaches: Motivation, engagement and sustainability in learning processes.

Sudarmilah, E., & Arbain, A. F. (2019). Using Gamification to Stimulate the Cognitive Ability of Preschoolers. Int. J. Innov. Technol. Explor. Eng., 8(6), 1250-1256.

Surendeleg, G., Murwa, V., Yun, H. K., & Kim, Y. S. (2014). The role of gamification in education-a literature review. Contemporary Engineering Sciences, 7(29), 1609-1616. https://doi.org/10.12988/ces.2014.411217

Sylva, K., Bruner, J. S., & Genova, P. (1976). The role of play in the problem-solving of children 3-5 years old. Play: Its role in development and evolution, 244-257.

Thiebes, S., Lins, S., & Basten, D. (2014). Gamifying Information Systems-a synthesis of Gamification mechanics and Dynamics. In ECIS.

Toda, A. M., Valle, P. H., & Isotani, S. (2017). The dark side of gamification: An overview of negative effects of gamification in education. In Researcher links workshop: higher education for all (pp. 143-156). Springer, Cham. https://doi.org/10.1007/978-3-319-97934-2_9

Tsai, F. H. (2018). The development and evaluation of a computer-simulated science inquiry environment using gamified elements. Journal of Educational Computing Research, 56(1), 3-22. https://doi.org/10.1177/0735633117705646

Udjaja, Y., Guizot, V. S., & Chandra, N. (2018). Gamification for elementary mathematics learning in Indonesia. International Journal of Electrical and Computer Engineering (IJECE), 8(6). https://doi.org/10.11591/ijece.v8i5.pp3860-3865

Umboh, D., Tarusu, D., Marini, A., & Sumantri, M. S. (2021). Improvement of student mathematics learning outcomes through Kahoot learning games application at elementary school. In Journal of Physics: Conference Series (Vol. 1869, No. 1, p. 012124). IOP Publishing. https://doi.org/10.1088/1742-6596/1869/1/012124

West, D. M. (2013). Mobile learning: Transforming education, engaging students, and improving outcomes. Brookings Policy Report, 9, 1-7.

Williams, I. (2010). Plato and education. The SAGE Handbook of Philosophy of Education, 69-84. https://doi.org/10.4135/9781446200872.n5

Wood, L., & Bennett, N. (1997). The rhetoric and reality of play: Teachers' thinking and classroom practice. Early Years, 17(2), 22-27. https://doi.org/10.1080/0957514970170205

Zakaria, N. S., Saripan, M. I., Subarimaniam, N., & Ismail, A. (2020). Assessing Ethoshunt as a gamification-based mobile app in ethics education: pilot mixed-methods study. JMIR serious games, 8(3), e18247. https://doi.org/10.2196/18247

Zaranis, N., Kalogiannakis, M., & Papadakis, S. (2013). Using mobile devices for teaching realistic mathematics in kindergarten education. Creative Education, 4(7), 1-10. https://doi.org/10.4236/ce.2013.47A1001

Zichermann, G., & Cunningham, C. (2011). Gamification by design: Implementing game mechanics in web and mobile apps. O'Reilly Media, Inc.

Zourmpakis, A. I., Papadakis, S., & Kalogiannakis, M. (2022). Education of preschool and elementary teachers on the use of adaptive gamification in science education. International Journal of Technology Enhanced Learning, 14(1), 1-16. https://doi.org/10.1504/IJTEL.2022.120556

Zsoldos-Marchis, I. (2020). Gamification of the mathematics course for pre-service preschool and primary school teachers. In Proceedings of 12th International Conference on Education and New Learning Technologies (pp. 6787-6794). https://doi.org/10.21125/edulearn.2020.1765