



Applications and Learning Outcomes of Game Based Learning in Education

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Abstract: Game-based learning (GBL) is considered the most engaging means of learning and brings several benefits as regards the learning outputs. Game-based learning is applied in all different educational stages from pre-school education to tertiary education, and workplace. This review study discusses and extends previous findings by organizing the application of GBL approaches in different educational stages and presenting the main learning outcomes. The review study collects and analyzes 104 scientific papers ranging from 2013-2021. The benefits and limitations of GBL are also discussed in the paper, while different types of games including augmented reality (AR) approaches are considered. According to the findings, in primary and secondary education, GBL demonstrates a positive impact on learning outcomes and engagement, enhancing students' understanding of complex concepts and fostering real-world application of learned knowledge. While GBL in tertiary education facilitates deeper understanding, critical thinking, and skill development, its implementation requires careful design and evaluation aligned with learning objectives. The study also explores various types of GBL games, including memory, simulation, interactive, quiz, puzzle, strategy, and reality-testing games, each tailored to different educational objectives and subjects. Furthermore, Augmented Reality (AR) in GBL shows promise across subjects but faces challenges like technical limitations, training needs, privacy concerns, potential distractions, and a lack of comprehensive research on its efficacy. Overall, while GBL demonstrates considerable potential in enhancing education, its successful implementation requires careful consideration of age-appropriateness, varied game types, and integration of emerging technologies like AR.

Keywords: Augmented Reality Game-Based Learning; Game-Based Learning; GBL in primary school, GBL in preschool education, Learning outputs

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Introduction

Games are considered to provide the necessary facilitation of the new educational demands in furthering students' knowledge in a particular subject in all levels of education. What is more, games can boost students' development in a way that is most practical in the rapidly changing world. Thus, the education and training of students that could claim to meet the requirements, should involve the use of innovative technologies and teaching methods that promote the development of their potential (Tokarieva et al. 2019).

If the implementation of educational methods involving the use of traditional games has quite a long history, it is relatively recently that technological innovations have marked the educational environment with their presence. With the advancement of technology and its integration in the everyday life of every person starting from a very early age, the notion of games in the learning process acquired a digital dimension. The review of the available literature on Game-Base Learning (GBL) has shown that, while the notion itself had been widely studied, it is, however, still quite early to claim that the processes related to GBL are fully examined at length.

Primary, secondary, and tertiary education contexts have witnessed varying degrees of success in implementing GBL. While primary and secondary education often sees positive impacts on learning outcomes and engagement, tertiary education leverages GBL to enhance advanced skill development. The effectiveness of GBL, evidenced by increased motivation, critical thinking, and subject comprehension, emphasizes its role in shaping educational paradigms. In preschool and primary education, the integration of GBL has historically faced skepticism. Concerns over young learners' cognitive and physical readiness for digital GBL activities have persisted. However, recent research emphasizes the potential benefits of non-digital GBL approaches for young learners, highlighting the significance of fine motor skill development before introducing digital technologies. Furthermore, GBL adoption faces nuanced challenges across different educational levels. While younger learners may benefit more from non-digital gamification, secondary and tertiary education often showcase higher adaptability and effectiveness of GBL, particularly in specialized fields such as science, business, and vocational studies. The study delves into various types of GBL games, categorizing them into memory games, simulations, interactives, quiz games, puzzles, strategy games, and reality testing games. Each game type offers unique educational benefits, showcasing a wide array of interactive tools to support learning across diverse subjects and age groups.

In addition to the above, Augmented Reality (AR) in GBL emerges as a promising but complex tool. While AR presents opportunities for enriched learning experiences, its implementation poses challenges. Issues related to technical limitations, training needs, data privacy, distractions, and limited research on efficacy necessitate a careful examination of its use within educational contexts.

Overall, researchers point out the need for further investigation of the application of GBL in education (Mayer, 2019).

The present paper attempts to convey a literature review that could further the analysis of the existing research. While giving a general overview of the existing practices and tendencies in the sphere of game-based learning in educational systems, the present paper will focus on the implementation of GBL in different stages (pre-school, primary, secondary, tertiary.) as well as the examination of the learning outcomes of its applications in various types of knowledge fields. The present paper deals with to the body of research concerned various types of games used in educational practices, in relation to their implementation through various levels of education, with particular attention given to the preschool and primary school education levels. The study also extends previous works by including Augmented Reality (AR) GBL application in the analyzed contexts.

In summary, this review aims to provide a comprehensive understanding of GBL's multidimensional facets and its evolving role in reshaping educational methodologies across various age groups, highlighting both its potential and the challenges it faces within contemporary learning environments.

Game Based Learning

According to Plass et al. (2015), GBL is type of learning pedagogy, which actualize the process of learning through the game. This type of learning activity has got defined learning outcomes. When addressed from the scientific point of view GBL can also be understood as an approach that has its origins in computer-simulation games used in guided-discovery teaching practices, that made use of the enormous cognitive stimulating and motivation boosting potential of computer-based technologies (Tokarieva 2019).

However, it would not be an overestimation to trace the origine of the GBL concept as far as 5000 year back, to the ancient civilization of the Roman Empire, Greece and China where didactic games were used to educated people in strategic thinking, taktical skills, mathimatics etc. (Hellerstedt & Mozelius 2019).

Game-based learning presupposes holistic integration of the concept of the game into educational processes. This means that it is not the games and their elements that are introduced into the education environment to achieve particular educational aims, but the education process is structured and performed through the game mechanism per se. Game-based learning (GBL) uses games to transfere information, synthesy knowledge and obtain skills through acheiving certian objectives predefined by the educational content. Main characteristic of GBL as an educational strategy is that it transends the rigid forms of conventional teacher-to-student education environment (Hellerstedt & Mozelius 2019). GBL introduces to the educational environment a new balance of educational content and safe and intertaining reproduction of situations that facilitate actual implementation of the experiential learning, promotes motivation, allows for tailoring the learning process to match particular needs (e.g. depending on tasks it could be autonomous and competitive work or collaborative group work) (Tokarieva 2019).

One of the main features of GBL are the multimodality of the used educational means (visual, audio channels of information provision are involved simultaniosly to convey certain information; what is more, the kinsethetic aspect of cognitive process are also involved to achieve the learnign goals). Another feature of importance is the interdisciplinary character of GBL methods.

Main principles of GBL are experienc-based aquisition of knowledge, the use of authentic materials, interchange of team work and individual work, cooperationa and competition and, finally, playfulness.

Games make players experience three different states:

Immersion is expressed in the feeling of engagement that a player develops while he/she is actively engaged in the activity of the game. The state of immersion is achieved when a player is completely absorbed in the activity and often loses track of time, while at the same time being recreationally satisfied.

- Flow is an experience of utter and total absorption in the activity (Höyng 2022, Silva et al. 2019).
- Presence is a feeling of being present in a game focusing mainly on the game's technological features. (Weibel et al., 2008)

Game Based Learning approach is based on the idea that learning is a process of achievement of pre-set objectives. It is the path that students take, with all the mistakes and downfalls, that adds value and content to the learning experience, as it is these aspects of the educational process that keep students engaged and motivated.

Another important part of game-related learning experience is the game elements (the protocol of simple and adequately set rules, rewards points, structure with clearly defined levels of difficulty etc.). It is widely noted that it is through a well-structured game, with adequately defined objectives, that students can achieve the final goal.

Additionally, it is important to mention the role of the feedback that students can get on an immediate basis during the well-organized game-based learning activity. The feedback provides an opportunity to consolidate the existing knowledge and re-apply it to correct the mistakes that were made during the completion of the set tasks.

One of the biggest assets of the GBL approach is that it introduces a certain aspect of flexibility in educational environments. If formal, conventional education environments favor teacher-centered approach, with the educator being the only organizational, educational and evaluation agent of the education process, with the introduction of GBL, the role of the student becomes more active due to the interactive mode that the educational process acquires.

In conclusion, the implementation of GBL in the classroom poses some significant challenges. One of the biggest of such challenges is deemed by many education specialists is the time and effort that it requires for preparation and actualization. (Zsoldos-Marchis & Hari 2020).

Gamification in Learning

Given the motivational properties of games, then, the appropriate application of their design principles and their respective elements in non-game environments has emerged as the most widespread and powerful technique for successfully shaping students' behavior (Deterding, Dixon, Khaled & Nacke 2011). This is commonly known by the term 'gamification'.

However, there is no consensus in the literature on a specific explanation of the term "gamification" and its corresponding scope of application. In some, even, studies do not include any definition for gamification design, explicitly or at least not explicitly mentioned (Raftopoulos 2014; Sakamoto, Nakajima & Alexandrova, 2012).

Another point of interest is the relationship between this term and technology, as in several studies it is considered that technology has an inherent relationship with the term "gamification" (Burke 2014; Ruhi 2015; Versteeg 2013; Wongso, Rosmansyah & Bandung 2014).

However, its application in education can be quite difficult due to some undesirable effects caused by the lack of proven design methodologies. So, before starting gamification design, it is very important to know specifically which frameworks or methods exist, as well as the main characteristics of this process.

The main elements of gamification design are therefore three and must be defined during the game design and, indeed, in a specific order (Hunicke, LeBlanc & Zubek 2004). First, the rules to be followed during the game (mechanics) are described, then the system of the specific game (dynamics) and finally, the fun to be derived through technological creations and modelling (technology-centered). However, these key elements of gamification design are largely based on the principles of game design theory. Salen and Zimmerman (2003), therefore, defined a set of fundamental principles of game design, which should be applied repeatedly during the educational process. Specifically, these principles are none other than understanding the design and interactivity of systems, creating an integrated and comprehensive study, as well as the connection between the rules, ideologies, meanings, and stories of a game.

Furthermore, it is worth noting that the goals of the gamification design elements are quite different from those of designing a game. It is based on two purposes, where the first one aims to enhance participation in different contexts, while the second one is directed only towards pure entertainment. Marczewsky (2014), in fact, makes a clear distinction between game design and gamification design, pointing out that the most common principle for a game design is the basic idea of enjoyment, while the main principle of gamification design is more business-like. Creating a gamified system is therefore quite different from creating a game, although there is generally a subtle connection between the two.

Methodology

A list of scientific papers was collected, indexed in Elsevier, Google Scholar, Springer, IEEE, ACM, and SCOPUS. The keywords used in the process include ‘game-based learning’, ‘game-based learning in education’, “game-based learning types” and “AR GBL”. The initial search was limited to articles published between 2010 and 2021, written in English, and focused on game-based learning in educational settings.

Table 1

Main inclusion and exclusion criteria for the thematic content of the analyzed articles

Inclusion criteria	Exclusion criteria
Game-based learning or gamification in educational settings.	Articles that did not focus on game-based learning or gamification.
Digital or traditional games for teaching and learning.	Articles that focused solely on game design or development.
Learning outcomes of game-based learning or gamification.	
Game-based learning in primary, secondary, and tertiary education.	

After the initial search, duplicates were removed, and the titles and abstracts of the remaining articles were screened for relevance. Articles that met the inclusion criteria were then read in full, and their references were reviewed for additional relevant articles.

During the analysis of the data, it became apparent that the timeframe limitation did not suffice for the purpose of the research implemented in the paper. Thus, articles with relevant information from earlier periods were also included. The final set of articles included in the review was selected based on their relevance to the research questions and their contribution to the understanding of game-based learning in educational settings. Almost 150 studies were selected and finally, 104 were analyzed in the current review. In the whole more than a hundred sources were analyzed (104), among which there were not only single articles and studies, but also 14 systematic reviews, meta-analyses, and literature overviews. The latter belongs to Chen et al. (2021), which was a systematic review of publications from a three-decade timeframe.

Results

Review of the analyzed scientific sources showed the variety of aspects, touched upon by the scholars include: digital game designs (Dehghanzadeh et al. 2021; Laine & Lindberg 2020, Zeng et al. 2020 etc.), analysis of cognitive, motivational and other effects of digital games (Al-Sudani 2019, Lu et al. 2022, etc.), game based curricular (Foster & Shah 2020, Vu & Fye 2020), GBL in various contexts (Yachin & Barak 2019, Pappa & Papadopoulos 2019, Park 2022), GBL and social aspects of its implication, including gender and culture (White 2020, Jossan et al. 2021), ways in which a conventional educational environment can integrate DGBL (Wang 2019, Zakaria et al. 2021) and the role of an educator (teacher/coach) in GBL (Chen et al. 2020, de Sousa 2021, Chakravarti 2020).

The present stage of GBL integration in educational context allows for such a multifaceted use of the method in teaching processes that even the previously excluded learning audiences now become more actively engaged during classes. For example, Bekshaev (2021) provides quite an extensive methodological and pedagogical analysis of GBL use for teaching biology to students with various types of disability (physical, mental, and emotional).

GBL in primary, secondary, and tertiary education

Scientific research has provided evidence for the effectiveness of game-based learning (GBL) in primary, secondary, and tertiary education. In general, GBL in primary and secondary education is believed to be able to provide a positive impact on students' learning outcomes and engagement. Also, studies have found that GBL can improve students' understanding of complex concepts and their ability to apply what they have learned in real-world situations. Research in tertiary education has shown that GBL can be an effective tool for engaging students in learning and improving their academic performance. For example, studies have found that GBL can increase students' motivation, engagement, and critical thinking skills, and that it can support students in developing a deeper understanding of complex concepts.

While the research on GBL in primary, secondary, and tertiary education is still growing, the evidence so far suggests that GBL can be a valuable tool for supporting student learning and development in these settings. However, it is important to note that not all GBL approaches are equally effective, and it is important to carefully design and evaluate GBL activities to ensure that they are aligned with learning goals and objectives. In further chapters the issue will be addressed in detail.

GBL in preschool and primary education

According to cognitive psychologist J. Piaget, GBL can be introduced for educational causes even at the earliest stage of human development, when game activities start to enter the cognitive and behavioral sphere of the human brain. At this stage, when children reach the age of 3 years old, they can actively engage in role playing in order to understand and analyze the processes and the real-world events that surround them. There are two main stages in the development of gaming activity. The first stage (when children reach the age of three till five years old) is characterized by the reproduction of the logic of people's real actions; the content of the game is the actions that are built around a particular object. At the second stage (when children reach the age five till seven years old) games are reenactment of social relations that people are engage in the real world, which means that the content of the game transcends that object relation and moves onto abstract phenomena (Kazantseva 2021).

There is quite a substantial body of research that addresses the preschool stage of learning through GBL approach throughout the world. Flashcards for a second language acquisition in the bilingual educational environment of Taiwan (Tang 2022) and gesture-based interactive virtual learning environment (VGVLE) in classes that teach color and shape to preschool children (Lie et al. 2018) are only few examples of the analyzed research queries that investigate the use of GBL approach in preschool environments. It is interesting to note that most of the queries that concern young learners address the GBL means that do not require the use of sophisticated digital skills. Further, the issue will be dealt with in more detail; for now, it is more important to introduce a general framework of the research on GBL in school education.

Previously, games were looked upon to build motivation and infuse the educational process (which sometimes tends to be somewhat dull) with entertaining elements that are inherent to games. Very few educators, researchers and/or game developers have tried to look at the situation from a different angle and to truly transform the learning process in accordance with the nature of the game. Thus, due to the absence of unified methods of interpretation and implementation of games in the context of education, there is significant divergence in the actual use of the GBL in practice. (Kafai, 2006).

Nowadays there is a plethora of evidence that suggests that GBL is effective even at primary school. Examples of modern games used in educational processes in elementary schools for literacy promotion (Schmidt et al. 2017), phonics (Savage et al. 2013), fluency (Giacomo et al. 2016) etc.

According to Razak and Connolly (2013), implementation of GBL in primary school environment shows slightly better results than the conventional methods of teaching. Their study was based on the comparative method, which showed that learning outcomes were better in groups where GBL was implemented. Another interesting point that the study made concerned the role of the teacher in GBL educational environment. The analysis of the results showed that in elementary school it was yet impossible to fully implement the said learning approach as students were simply not ready to work without active help of the mediator (the teacher).

In respect to the application of GBL methods in educational environments that involve young learners it should be said that the previous body of research shows that there was quite a large amount of doubt on the positive effect of GBL. Scholars used to juxtapose young learners' involvement with screen-related activities to conventional learning (e.g., reading) with the latter being viewed as activities that are proven to be effective.

Studies with learners of older age found that activities that implement the use of computers, help children develop independent learning and reading skills, but there was still no convincing evidence that it was positively influencing the general academic development. What is more, there was a significant amount of concern related to the potential involvement of other, non-academic, and even inappropriate content during the individual students' work with the in-question programs. In many of the analyzed sources it was pointed out that the underdeveloped symbolic and abstract reasoning abilities in learners of younger age (especially of pre-school learners) might render the time spent on screen-related educational activities unproductive and even irrelevant to educational environment (Schmidt et al. 2017).

Other studies in the sphere were concerned not only with cognitive capabilities of younger learners, but also with their physical abilities. Thus, some researchers make a logical statement that for the GBL activities to be beneficially implemented in classes with younger learners (especially with preschool-aged students), they need to possess fine motor skills (Fisch 2016). This means that while such skills are underdeveloped, the GBL could potentially be irrelevant or redundant for students till at least they reach the age of 4, when most children can use digital technology and related to it hardware independently. Thus, the age of four is deemed by most scholars as an appropriate threshold for the introduction of digital game-based learning activities in the educational environment. Earlier than that, it is deemed unreasonable and even useless for young learners to be involved in such types of activities, as they might struggle to even access the to-be learned material (Fisch 2016).

A preliminary conclusion regarding the approach that research takes to the use of GBL in educational environments with learners of younger age (preschoolers and elementary schoolchildren) is far from being positive. Multiple research data argues that due to the developmental characteristics (cognitive, physical, social etc.) of the analyzed audiences, the use of digital GBL (DGBL) has dubious benefits as the learners are simply not able to properly use it in practice. The role of the teacher at that age still plays quite an important role and thus it is yet early to speak about total integration of the pedagogical method at the stage. Elements of gamification, however, as well as non-digital games are more commonly used in educational processes with young learners.

GBL in secondary and tertiary education

The data of the analyzed research shows that Game-based learning can be used effectively in both secondary and tertiary education to engage students and facilitate learning. In secondary education, game-based learning can be used to introduce students to new subjects and concepts in a fun and interactive way. For example, games can be used to teach students about history, geography, science, and other subjects in a way that is both engaging and informative. Additionally, games can be used to help students develop key skills, such as critical thinking, problem-solving, and teamwork. In tertiary education, game-based learning can be used to support the development of more advanced skills and knowledge in specific fields, such as engineering, computer science, and business. For example, simulations and games can be used to provide students with hands-on experience in decision-making, risk assessment, and strategic planning. In this way, game-based learning can help students to develop a deeper understanding of complex concepts and prepare them for careers in their chosen fields.

In secondary education the results of a survey that involved upper secondary and higher education show that, despite the inconsistent data on the learning outcomes aspect, GBL has quite a potential with the students of the target age. In particular “students’ performance expectations are found to promote learning engagement. Thus, GBL is suitable if the target group can recognize the content-related benefit, and if the content is designed to be challenging” (Platz 2022).

Another study, results of which are relatively consistent with the previous one, state that GBL methodology, which involves using game development to teach programming, motivated students to a great degree. What is more important, however, is that the study considers the etic approach to the evaluation of the effectiveness of GBL in educational environment, which means that both teachers and experts (that participated in the research) find GBL effective in reaching the stated educational goals. The findings suggest that GBL is applicable and suitable for lower secondary students, who are 11-15 years old. This is important because it indicates that game-based learning can be used effectively in this age group to support the development of programming skills, which are increasingly important in today's digital world (Holenko & Hoic-Bozic 2021).

In tertiary education GBL is used in more narrow and specialized academic studies. One of the most widely researched areas regarding the use of GBL in tertiary education is the area of science (physics, chemistry etc.). An interesting overview is given on the matter by Dabbous et al., who having studied and analyzed several scientific literary sources, were able to make an impressive list of actual examples of GBL implementation for professional training of pharmacy students in various higher education establishments of the world. Among quite a large scope of digital games, mentioned by Dabbous et al. were tactical digital environments, that reproduced actual pharmaceutical processes for students to be engaged at; a 3D simulation game, that show the operational minutia of a pharmacy, an innovative escape room environment that facilitates toxicology teaching objectives; quizzes and competitions (one of them on the platform Kahoot!) and many more other games (Dabbous et al. 2022). Such a wide range of digital means

applicable in GBL shows that the integration of the pedagogical method is quite deep even at such a specialized sphere as pharmacy studies.

Digital games in education (e.g., business stimulation games) allow students of tertiary level of education to engage in a learning process with a larger amount of positive feeling. The interactive mode of such games allows for the educational process transition into a quite an enjoyable mode and highly interactive mode. (Buil et al., 2019; Pando-Garcia et al., 2016 etc.). Digital games of the above-mentioned type, recreate a real life experience, related to business sphere and thus engage students in active learning (Matute & Melero, 2016).

The most recent research gives substantial evidence that GBL is beneficial to such aspects as vocational education as students' academic performance, participation and motivation (Dahalan et al. 2023).

Finally, in their literature review on research concerned with the effects of game-based learning in the acquisition of "soft skills", Garcia et al. (2020), state that the development of digital games can facilitate not only academic (or practical) knowledge acquisition, but also "promote the acquisition of more than one soft skill which is beneficial for undergraduate students" (Garcia et. al. 2020).

Types of GBL games

Studies on GBL types of games show profound interest of specialists all over the world on the matter. Schmidt et al. note that countries like Australia, the USA, Finland, France, Israel, the Netherlands are among those who are actively involved not only in implementation of the game-based learning methods in educational environments, but also in creation of educational game-based platforms for young learners. What is more, it is stated that the initiative for promotion of such programs comes from not only private investment sector, but also from federal government reserves (Schmidt et al. 2017).

Another finding of the systematic review, conducted in the framework of the present paper, show the quality and relevance of the developed for the educational purposes' digital environments (computer games, platforms etc.) are subject to diachronic evolution, just like any other educational methods. In particular, the analyzed studies show that with the development of the technology educational games improve in respect to the quality and efficacy to the learning needs of students that use them. In the sphere of literacy development, it could be said that, while it was claimed that games that were used in the 2000's had relatively inconsequential effects on literacy development (Torgerson, 2007), in later years the tendency seems to improve.

According to Kirstavridou, et al. there are seven types of games used in the Game-based learning (Kirstavridou, et al. 2020):

Memory games (e.g., Duel, AppQuiz etc.) Memory games can be highly effective in improving and maintaining memory abilities, as they provide opportunities to practice and strengthen memory skills in a fun and engaging way.

They can also be educational, as they can help players learn and practice information that they might not otherwise encounter, such as new vocabulary words, historical facts, or geographical information. Memory games can be found in many different forms, including electronic versions available on websites and mobile devices, as well as traditional memory games, such as matching cards or memory puzzles.

Simulation games (e.g., Plantville, SimCity, SHOOT!) In a simulation game learners could be presented with a variety of scenarios that simulate real-life situations. There is a multitude of simulation games created for the educational environment which means that each game is tailored to meet the goals of a particular subject. For example, in their overview of simulation games, created for veterinarian students, De Bie & Lipman (2012) refer to 63 simulation games. Some of them recreate situations where learners need to diagnose and treat animal illnesses, perform surgeries, or manage a veterinary practice. Through these simulations, students could learn and practice key concepts, procedures, and decision-making skills in a hands-on, interactive way (De Bie & Lipman 2012).

Interactives (e.g., Funbrain) Funbrain is a popular educational gaming website that offers a wide range of games for students of different ages and subjects. Some of the games on Funbrain can be used to reinforce skills in areas such as math, reading, and problem-solving. In GBL, interactive games are used as a teaching tool to engage students and make learning more enjoyable. These games often involve active participation, such as answering questions, making decisions, or solving puzzles, which can help students retain information and develop critical thinking skills. Funbrain and similar websites offer a variety of interactive games that can be used for GBL, making it easy for teachers to incorporate game-based learning into their lessons. These games can be used as a supplement to traditional classroom instruction or as a stand-alone learning tool (Gillen et al. 2022)

Quiz games (e.g., Kahoot!). According to Chiang (2020), Kahoot! seems to be quite an effective tool that can facilitate the educational process in various ways. It can engage learners through problem learning, provide meta-cognitive support, develop and improve critical thinking and provide meaningful and entertaining activities. What is more, Kahoot! can also be used in review of the content knowledge (Chiang 2020).

Puzzles (e.g., Crossword) Crossword puzzles can be considered educational games, as they provide opportunities for learning and mental exercise. Additionally, crossword puzzles can also help develop critical thinking and problem-solving skills, as players must use logic and deduction to determine the correct answers. Crossword puzzles can also be highly motivating, as they provide a sense of accomplishment and satisfaction when players are able to successfully complete a puzzle (Kabilan 2022).

Strategy games (e.g. Europa Universals, Civilization) Strategy games can help develop critical thinking, problem-solving, and decision-making skills. They can also provide opportunities to learn about history, geography, economics, and other subjects, as many strategy games are based on historical events or situations. In addition, strategy games can also help develop strategic planning and risk management skills, as players must consider the long-term

consequences of their decisions and actions. They can also provide opportunities for collaboration and competition, as many strategy games allow players to work together or compete against each other in multiplayer mode.

Reality testing games (e.g., Chemistry VR, AtomView, Fantastic Contraption etc.). The use of VR technology provides a unique and immersive learning experience that can be highly engaging for students. Areas of application of VR games can vary from design, second language, and chemistry to cultural studies and medicine.

There are various classifications of educational games (Kuryshева 2009). According to the classification based on the purpose of use, educational games can be (Gelman 2020):

Edutainment games (term, coined from words “entertainment” and “education”),

Business games, which are further divided into simulation, operational, role-playing and drama (theater).

Edutainment games have at their core the idea that the learning process is not necessary to take place in a formal (often boring) setting. On the contrary, they are aimed at combining elements of entertainment with the acquisition of knowledge. This approach has led to the emergence of Edutainment learning technology (De Vary 2008).

Serious games are another type of educational game, which is gaining popularity at all educational levels and beyond. For over a decade now, serious games have been actively used by educational specialists even as early as at the secondary education level. Brom et al. (2010) state that one of such games (Global Conflict: Palestine) served as a useful tool for engaging students in social science courses, in teaching them basic concepts of politics, economy and other social issues that are relevant not only to the present Europe, but to the whole world in general. (Brom et al. 2010)

Augmented Reality and Learning

There are many interpretations of the notion of Augmented Reality. The existing diversity in interpretation of the notion, however, does not hinder a one, generally accepted by most theorists, line of understanding of the notion of Augmented Reality as an experience created by enhancing or overlaying the physical world with digital-virtual objects (Challenor & Ma 2019, Bezegova, 2017, Schueffel, 2017).

Augmented Reality Game-Based Learning (AR GBL) is used for description of the use of Augmented Reality in a learning context (Tobar et al. 2017). Augmented Reality Game-Based Learning is learning based on augmented reality games. According to Alper et al. AR GBL is mostly used in such educational domains as: Science, Math, Language learning, Informational Technologies – Computer Science, History - Geography – Astronomy, Health – Medicine, Engineering – Architecture, Educational Sciences – Instructional Design, Special Education and Communication (Alper et al. 2021).

A systematic literature review (Pellas, et al.2017) on the use of PE in combination with gamification only reports outcomes for primary and secondary education and does not include any case of adult education. A more recent literature review on the educational use of AR in history and museum education by Challenor & Ma (2019) focuses on a) history education, b) Holocaust history education and c) museums.

In relation to its educational use, a systematic review in the field of school education showed that AR GBL can do the following (Alper et al. 2021):

- give teachers new ways to present relationships and connections (Yuen et al., 2011),
- provide a richer learning experience (Liu and Chu, 2010) .
- increase student motivation (Winkler et al., 2008, Liu and Chu, 2010, Bujaket al., 2013, DiSerioetal., 2013).
- improve the flow of learning (Chiang et al., 2014)
- contribute positively to the overall learning experience (e.g., Chen et al., 2017, Tobar-Muñoz et al., 2017).

Yilmaz & Goktaz (2018) list a series of research findings according to which Augmented Reality offers a sense of reality, spatial abilities, visualizes complex relationships, offers experiences that cannot exist in real life, concretizes abstract concepts, makes learning fun, presents a safe learning environment, saves space, increases student participation and finally, offers flexibility. Additionally, Alper et al. point out at increase in students' communication, willingness to learn, development of the collaborative work, provision of fast feedbacks (Alper et al. 2021).

While AR can have many benefits in education, it's important to consider the limitations and challenges that come with it as well. One such challenge is the potential for cognitive overload for students. AR adds another layer of information and interaction to the learning process, which can be overwhelming for some students. Additionally, AR technology can be difficult to manage and use effectively, both for teachers and designers. This requires training and resources that may not always be available, which can limit the widespread adoption of AR in education. (Alper et al. 2021).

Another limitation of AR is that it can be costly to develop and implement, especially in terms of hardware and software requirements. Furthermore, there is a lack of standardized AR content and guidelines for use in education, which makes it challenging for teachers to effectively integrate AR into their lessons. Overall, while AR has the potential to revolutionize education and enhance the learning experience, it's important to carefully consider the limitations and challenges and to invest in resources to overcome them. (Alper et al. 2021). Finally, Chiang et al. (2014) consider as more important the failures of geo-location systems (GPS), which do not perceive changes in location or direction.

In the whole, it could be concluded that AR in GBL research can be summed up in the following statements:

- There are multiple technical limitations ascribed to the GBL means applications as AR technology can be costly, demanding in maintenance and difficult to use (because of the complex and confusing interface). These technical

features of AR can have serious negative impact on learning processes, including students and teachers' frustration and reduced engagement with the learning material.

- To use AR technology in teaching and learning, educational professionals need adequate training, lack of which might cause problems in the process, including reduced effectiveness of the AR as a learning tool.
- AR technology can collect and store sensitive personal data, which raises privacy and security concerns for both students and teachers.
- AR can be distracting and may not be appropriate for all types of learning activities, especially for tasks that require focused attention and concentration.

Finally, there is still limited research on the efficacy of AR in learning, and more research is needed to fully understand its potential benefits and limitations.

Learning Outcomes

The use of game-based approaches in education can lead to a range of learning outcomes. Some of the key benefits include the following:

Increased engagement and motivation: Games are often more engaging and motivating for students than traditional teaching methods, which can help to increase their overall involvement and interest in the subject matter (Boyle et al. 2017). It has been claimed that an increased sense of motivation is developed in students through actively participating in gaming activity (Dabbous et al. 2022). Moreover, activity design is an important factor in successful engagement within argumentative discourse (Noroozi et al. 2016) and digital dialogue game can guide students towards a desired mode of interaction and argumentative discourse (Noroozi, 2016). What is more, some studies show that students who engage in Game-based Learning (GBL) often need to put in additional effort to assimilate the material they have studied. This is because games are designed to challenge players and require them to think critically, problem-solve, and make decisions. This active and engaged learning experience can lead to deeper understanding and retention of the material. (Liu et al. 2020)

Developing and improving problem-solving skills: Games often require players to solve challenges and problems, which can help students develop their critical thinking and problem-solving skills (Li & Tsai, 2013).

Enhanced collaboration and teamwork: Many games require players to work together to achieve a common goal, which can help students develop their collaboration and teamwork skills (Boyle et al. 2016).

Better memory retention: Games often involve repeated interactions with information, which can help students retain and recall information more effectively (Boyle et al. 2016).

Development of digital literacy skills: As more and more games are played on digital devices; students are exposed to technology and develop their digital literacy skills (Boyle et al. 2016).

Improved decision making: Games often require players to make decisions that impact their success, which can help students develop their decision-making skills (Boyle et al. 2016).

Development of creativity: Games often involve creative problem-solving, which can help students develop their creative thinking skills (Boyle et al. 2016).

Although educational game studies reveal varying degrees of success depending on the academic subject, student preferences, and age of participants (Hays, 2005), GBL tends to positively affect attitudes and cognitive development of learners. It's important to note that not all game-based approaches will result in these outcomes for all students, specifically, Khan et al. (2017), note that the potential differences in the learning outcomes might even be related to the gender of students as in their case study on the matter girls seem to outperform boys. Also, the specific learning outcomes will depend on the nature of the game and the goals of the educational program. However, game-based approaches have the potential to provide a fun and engaging way for students to learn and develop a wide range of important skills (Khan et al. 2017).

For GBL approach to be applied to its maximum potential, it should not only engage learners in content lessons, but also involve them in the process of developing skills and knowledge of universal character. This factor is important as when the learner advances through the game, he/she needs to integrate both the subject expertise and the general knowledge and skills.

There is a plethora of empirical evidence on how games in the classroom influence the development of 21st century skills. The skills associated with the 21st century differ dramatically from the skills valued by the education system and include (Binkley et al., 2014): critical thinking (comprised of scientific reasoning, systems thinking, computational thinking, decision making, and problem solving), creativity (comprised of divergent thinking, innovative thinking, originality, inventiveness, and the ability to see failure as an opportunity for improvement), collaboration is related to the ability to work effectively and respectfully with diverse groups, to be flexible and willing to compromise towards achieving goals and taking shared responsibility, communication, which is understood the ability to structure thoughts and ideas in various forms, to communicate for various purposes and in different settings, and to use multiple media and technologies (Binkley et al., 2014).

Also, the positive effect of GBL on the learning outcomes is observed not only regarding the acquisition of 21st century skills, but also in the educational area concerned with overcoming certain cognitive and developmental disabilities. For example, Garcia-Pedondo et al. (2019) showed that there seem to be potential for students with attention deficit, educational video games can provide an engaging and dynamic learning environment that helps maintain their focus and attention on the task at hand. Additionally, many educational games are designed to provide immediate feedback and rewards, which can help students with attention deficit stay motivated and engaged in their learning.

According to the analyzed data, the implementation of GBL pedagogical method at all levels of educational system is known to bring about better learning outcomes (Razak & Connolly 2013). With it, however, the prevailing part of the analyzed literature points out the need for further investigation of the correlation of various factors that might influence learning outcomes of GBL implementation in practice. For example, in an overview of compute games implementation in education the following contingent factors were pointed out: data on the learning outcomes should consider results that the players of base version of the game have compared to those, that played an enhanced version of the very same game. The invariant factor should also be considered when learning outcomes are studied through comparison of the use of the conventional material to the material based on the GBL approach (Mayer 2019).

Though the biggest part of the analyzed research on the learning outcomes states the overall positive effect that GBL approach has on the expected learning outcomes of the participants, all of them still cite several limitations that to a certain degree decrease the impact and potency of the in-question method.

Subject of investigation: In the educational environment it usually translates either to the age of the involved group of learners, or to the subject they study per se.

Difficulty in measuring outcomes: Measuring learning outcomes in GBL can be challenging because it often involves complex and multi-faceted experiences that are difficult to quantify. For example, it can be difficult to measure changes in attitudes, motivation, or engagement, which are important components of GBL.

Variability in game design: The design of GBL games can vary greatly, making it difficult to compare results from different studies. This variability can include differences in game mechanics, content, and learning goals, which can have a significant impact on learning outcomes.

Small sample sizes: Many studies of GBL have small sample sizes, which can limit their generalizability and make it difficult to draw meaningful conclusions about the effectiveness of GBL as a pedagogical approach.

Short duration of interventions: Some GBL studies are of short duration, often lasting only a few hours or days. This can make it difficult to determine the long-term impact of GBL on learning outcomes.

Lack of control groups: Many GBL studies do not include a control group, making it difficult to determine the specific impact of the game on learning outcomes and to account for other factors that may be contributing to changes in outcomes.

Another factor that is often mentioned as limiting to the resulting generalization is the demographic aspect of gender or cultural reference.

Despite these limitations, there is still a growing body of research that suggests that GBL can have a positive impact on learning outcomes. However, more rigorous and well-designed studies are needed to build a stronger evidence base for the use of GBL in education.

Benefits and disadvantages of GBL

Just a few years ago research noted that digital game-based learning has no major advantages over the conventional means and methods of education (Wouters & van Oostendorp, 2013). Some of them went as far as claiming that there were some serious problems related to the implementation of games in educational processes. Among the problems there were ones related to the refusal of acknowledgment of potency of the game methods in educational environments. Others were related to the difficulties related to the transition from the traditional comprehension of how learning objectives should be achieved to the innovative interpretation that gaming incurs for education. Another group of problems that the previous years of research used to come across was concerned with the (im)probability of implementation of knowledge and skills, gained from game-based learning in contexts that the real-world experiences incur (Cyril et al. 2010).

More recent research on the matter, however, dismantles most of the concerns as irrelevant to the actual results, claiming that Game-Based learning has tremendous positive effect in respect to the application of the gained knowledge to the facilitation of real-life problems. Special emphasis is placed in this respect to the business simulation games (Buil et al., 2019; Vidergor, 2021 etc.).

Reasons for such a positive interpretation of the potential that Game-Based learning has for the creation of knowledge and skills that are useful in real-life situations are also a topic of research that attracts major attention. Some of them claim that GBL boost students' performance because it activates a multitude of learning mechanisms (affective, cognitive, behavioral) (Koivisto & Hamari 2019, Sailer & Homner 2019, etc.). There is also substantial evidence that proves the beneficial character of GBL because it helps develop the social skills of the players. Besides that, the authentic learning experience provided by GBL implementation in educational environments boosts system thinking, promotes learning that is based on collaborative search for solutions of problem set by the tasks (Gros 2007).

Now, when the beneficial side of the implementation of the Game-based learning approach is discussed, it is necessary to address the other side of the method. In general, the analysis of the literature allowed for the following disadvantages and weak points of GBL implementation in educational environment to be distinguished:

Cost: Creating high-quality game-based learning experiences can be expensive, as it requires significant resources, such as specialized software and design expertise. (Hainey et al. 2016, Sousa 2022).

Limited engagement: Some students may not find games as engaging as other forms of learning, and they may lose interest quickly (Ifenthaler 2012).

Limited transferability: While game-based learning can help students acquire certain skills and knowledge, it may not always translate to real-world applications or other areas of learning (Jinot 2019).

Technical difficulties: Technical issues, such as compatibility problems or internet connectivity issues, can limit the effectiveness of game-based learning.

Limited diversity: Some game-based learning experiences may not be inclusive or culturally sensitive, which can be a barrier for some students (Riopel 2019, Bakan & Bakan 2018).

Lack of personalization: Game-based learning is often designed to be a one-size-fits-all experience, which may not be suitable for all learners (Holenko & Hoic-Bozic 2021).

Game addiction: Some students may become addicted to playing games, which can negatively impact their overall learning and well-being (Mayer 2019).

Teachers/educational professionals are not interested in the process of teaching through games and/or do not regard as useful and practical method. The issue with teachers is also that they might not have access to the time/funding/knowledge to implement GBL method in their classes (Plecher 2020).

Not all categories of students can equally participate in GBL as there is age, cognitive/developmental and other types of restrictions and limitations to its use at least for the present stage of its development (Tang 2020).

Table 2 summarizes the main benefits and limitations of GBL. While GBL offers benefits like enhancing problem-solving skills, various learning mechanisms, and social skills, it also faces drawbacks such as high costs, limited engagement for some students, challenges in transferring knowledge to real-world situations, technical issues, inclusivity concerns, lack of personalization, potential for addiction, resistance from educators, and limitations for specific student categories.

Discussion and Practical Implications

The extensive review of research studies on various educational levels reveals profound implications for the integration of Game-Based Learning (GBL) across primary, secondary, and tertiary education. Findings suggest that GBL demonstrates promise in enhancing learning outcomes, engagement, and skill development. In primary and secondary education, GBL exhibits potential for improving understanding, engagement, and critical thinking skills, while in tertiary education, it facilitates hands-on learning experiences and specialized skill development, particularly in science, business, and vocational studies.

Table 2

Benefits and disadvantages of GBL

Benefits of GBL	Disadvantages of GBL
Facilitates real-life problem-solving applications	Costly development and implementation
Enhances various learning mechanisms (affective, cognitive, behavioral)	Limited engagement for some students
Develops social skills and promotes collaborative learning	Limited transferability to real-world applications
Provides authentic learning experiences	Technical difficulties and compatibility issues
	Lack of inclusivity and cultural sensitivity in content
Boosts system thinking and problem-solving skills	Lack of personalization for different learner needs
	Potential for game addiction affecting learning
	Resistance from educators and lack of implementation support
	Restrictions and limitations for certain categories of students

In preschool and primary education, while initial skepticism existed due to concerns about developmental readiness and screen time, recent research highlights that GBL, especially non-digital formats and elements of gamification, can be beneficial after the age of four, aiding in skill development and engagement. Moreover, the specific types of GBL games, ranging from memory, simulation, interactives, quiz, puzzles, strategy, to reality testing games, have been developed and refined, catering to various educational objectives and age groups.

However, challenges persist, particularly in the integration of Augmented Reality (AR) within GBL. Technical limitations, costs, privacy concerns, and the need for specialized training hinder the seamless incorporation of AR into educational settings. Additionally, cognitive overload and distractions pose potential obstacles to effective learning through AR. In summary, this study concludes that while GBL showcases potential benefits in diverse educational settings and levels, careful consideration of the nuances and challenges, particularly concerning AR integration, is essential.

The results of this study significantly contribute towards the deeper understanding of the benefits and limitations of GBL or gamification in different educational levels. Educators, researchers, and institutions might find useful guidance on when and how to apply GBL approaches for their needs and context.

Further research is needed to address these challenges and unlock the full potential of GBL, ensuring its optimal use in enhancing educational experiences and outcomes.

Conclusion

The results of this research suggest that competition in digital game-based learning (GBL) is effective in certain subjects and for certain types of games. The findings show that competition in GBL was effective for math, science,

and language, but not for social science and other subjects. This suggests that the effectiveness of competition in GBL may vary depending on the subject matter being taught. The research also found that competition in DGBL was effective for students at all levels of the educational system. This indicates that GBL can be a useful learning tool for students of different ages and skill levels. The type of game used in GBL also appeared to be important in determining its effectiveness. The research found that competition in puzzle, strategy, role-playing, and simulation games was effective, but not in action games. This suggests that certain types of games are better suited to promoting learning through competition than others.

Finally, the research found that competition in GBL was equally effective for both cognitive and non-cognitive outcomes. This suggests that GBL can be used to promote both cognitive and non-cognitive skills, such as motivation and engagement, among students.

The implementation of game-based learning (GBL) in education can present several challenges for both teachers and students. The creation of games can be time-consuming and require additional teaching hours to learn how to implement them. Additionally, the materials required for implementation can range from low to high value, and the acceptance of this approach by the entire school community can also be a challenge. However, despite these challenges, the benefits of GBL are substantial and should not be ignored. GBL has been shown to increase student engagement, motivation, and attention, and to facilitate seamless learning and retention of information. GBL has also been shown to promote creativity, problem-solving skills, and collaboration among students. The impact of educational video games on student learning and engagement is complex and multifaceted and requires a holistic and interdisciplinary approach to both game design and research.

The cognitive perspective focuses on the content and processes of learning, such as knowledge acquisition and problem-solving. The motivational perspective focuses on the student's intrinsic and extrinsic motivations for learning, such as their interests and goals. The affective perspective focuses on the emotional and affective dimensions of learning, such as engagement and enjoyment. And the sociocultural perspective focuses on the social and cultural context of learning, such as peer interaction and cultural norms.

A combination of these perspectives is necessary to fully understand and harness the potential of GBL for learning. For example, a well-designed educational video game should not only provide opportunities for knowledge acquisition, but also engage and motivate students, create a positive affective environment, and provide opportunities for social interaction and cultural exchange.

In educational environments, GBL is often used to support students in learning specific subject matter or skills, such as history, mathematics, or critical thinking. GBL in educational environments is typically focused on student-centered learning and can take many forms, including digital games, tabletop games, and simulations.

Future research should consider exploring diverse types of GBL, including augmented reality (AR), computer games, and their enhanced versions, in comparison to conventional educational methods. By conducting comparative studies, researchers can unveil a more comprehensive understanding of the efficacy of GBL in education, considering its advantages and limitations. Despite challenges, GBL stands as a valuable approach in education, offering substantial benefits that warrant its consideration in promoting student learning and engagement.

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