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Application Of Serious Games And Digital Game Based Learning (DGBL) In Higher Education: A Systematic Review

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ABSTRACT

This paper presents a systematic review on the use of serious games (SGs) and digital game-based learning (DGBL) in higher education across various disciplines. The aim of the review is to identify research gaps and summarize the current status of the use of SGs in higher education, including growth over the years, applications across different regions, types of games applied, research methods used, and acquisition of results. Using the PRISMA 2020 guideline, a total of 211 research papers were found from the three databases (Scopus, Google Scholar, Web of science). After applying inclusion and exclusion criteria for filtration, 16 papers were finally selected for review. The review found that the application of DGBL and SG in higher education resulted significant improvements of learning outcomes and academic achievement. However, there are still significant research gap in exploring tertiary or vocational education in different disciplines. The existing researches focus on targeted outcomes but rarely identifying other learning outcomes from DGBL and SG. This review paper concludes that future research needs to focus on exploring the impact of DGBL and SG on a wider range of learning outcomes while strengthening the applied approach in different disciplines of knowledge.

Keywords: *Digital Game-based Learning (DGBL), Serious Games (SGs), Systematic Review, Higher Education*

INTRODUCTION

Playing can be functionally interpreted as an act subordinate to adaptive intelligence (Piaget, 1976). With the development of digital media, playing is allowed to occur in a wider range of contexts (e.g., digital games). The integration of digital games with education is known as 'serious gaming'. Serious games are defined as games with a clear and thoughtful educational purpose, instead of mainly for entertainment (Abt, 1987). Many serious games are designed for educational purposes, such as training, medical and health research, and commercial applications. Thus, serious gaming has a lot of potential in higher education. Meanwhile, Digital Game-based Learning (DGBL) is a student-centred approach to learn through playing digital games (Prensky, 2007), with supported educational theory. Playing is a constructivist approach to learning and gaming is more inclined to a behaviourist approach to learning (Ali Turker, 2016). Sandberg, Maris and Hoogendoorn (Sandberg & Hoogendoorn, 2014) claimed that DGBL refers to learning by solving problems or accomplishing tasks through computers, mobile phones, or tablets. There are several elements in DGBL, such as fun, play, goals,

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competition, and problem-solving. Therefore, DGBL approach explores the meaning and purposes of playing. Several studies approach the topic from different perspectives and use different terms, such as playing, video game learning, PC game learning, online game-based learning, and game-based learning (Pho & Dinscore, 2015; Kirriemuir & McFarlane, 2004; Jong, 2015). This discourse is not new but necessary since there is still research gap on DGBL for higher education.

Literature Review

Many previous studies have shown that motivation and efficacy of learning could be increased through DGBL (Frøland et al., 2022; Hussein et al., 2019; Vila & Soledad Carenys, 2017). Tari, Shams & Rezaeizadeh (2017) argue that motivation is an important factor that influences learning. Apparently, video games have influencing motivation among young generations. Meanwhile, there is increasing research on the impact of games for educational purposes (Hwang & Wu, 2012). Many researchers claim that games could help to enhance learning process and enrich the learning outcomes. The combination of games and education has been reported as having positive implications in many areas, such as student performance, engagement and motivation. Therefore, this led many researchers to focus on the game-based educational or play-based learning approaches, in which Prensky (2001) named it as DGBL. Some studies have also claimed that game-based learning has positive pedagogical effects for both low and moderate academic achievement students, but not for high academic achievement students (Jong, 2015). The introduction of DGBL has become important in the teaching and learning process.

The U.S. Department of Education has funded numerous research projects and initiatives focused on the use of serious games in education. For example, its Office of Educational Technology has funded the "Games, Learning, and Assessment (GLA) Lab," which conducts research on the use of digital games in education and develops recommendations for educators (Erhel & Jamet, 2013). However, developing an educational game is a difficult task. The 'seriousness' of serious games depends on their purpose (Haring et al., 2011). Therefore, many researchers have started exploring the potential use of commercial games for educational purposes. According to Blumberg et al., (2012), while serious games are intended for education or training, commercial games that able to teach important content and knowledge to players should also be considered as serious games. Such a conclusion could lead to more games being used in education. Later in 2017, Lameras et al., (2017) claimed that SGs could also be used for teaching specific subjects, modules or knowledge and skills on a particular topic. Games are appealing to many young learners due to their interactive, participatory and engaging nature (Del Blanco et al., 2012). Meanwhile, the different challenges and problem-solving approaches faced in games (De Freitas, 2006) have led to the hypothesis that games could be used to enhance learning and teaching in different areas of professionalism (Giannakos, 2013). Therefore, exploring the use of serious games or DGBL in higher education definitely worth for study.

The term DGBL was first coined by Prensky (2001) and refers to any form of using or integrating digital games in a learning environment. DGBL is an instructional strategy that could be implemented through computer-based applications. Through advances in learning technology over the years, DGBL could be considered as a stand-alone learning environment that could cater for different levels of learning (Hwa, 2018). Today, DGBL has increasingly been used in higher education as a method to engage students and improve their learning experience. DGBL uses digital games to engage and motivate students. Meanwhile, the scope of DGBL research is very broad. It could be a serious game application with a pedagogical

goal; a game activity designed for students exploring a topic; or a commercial off-the-shelf (COTS) digital game to achieve learning objectives (Van Eck, 2006). With the attributes of COTS games, adoption of DGBL in educational settings has been discussed more extensively. With the categorisation of different games by Apperly (2006), researchers have subsequently looked into the impact of game types for education, such as RPGs and 3D simulation games being considered as more educationally appropriate game types Vlachopoulos & Makri, 2017). Coffey (2009) argues that DGBL is defined as educational content or learning principles incorporated into a video game. Game-based learning diversify education, increase student interest and motivation, and provide a positive and effective learning experience. Generally, DGBL is accepted as an effective educational tool to improve the future of classroom education.

As DGBL continues to develop, there are many scholars who believe that learning through DGBL has many advantages, such as, increasing engagement (Cai et al., 2022), improving problem solving skills (Toprac, 2011), enhancing collaborative skills (Romero et al., 2012), and provide personalised learning (Cheung & Slonje, 2013). Connolly et al., 2012 proposed a framework to analyse serious games and its dimensions such as knowledge acquisition, skill acquisition, affect, motivation, learning outcomes and behaviour change aspects, and helps researchers to develop strategies in enhancing the effectiveness of learning (Hussain et al., 2014). Carenys & Moya (2016) reviewed the application in a specified discipline (i.e., accounting and business education), while Vlachopoulos & Makri (2017) reviewed learning simulation through games in higher education.

This paper is divided into four main sections: introduction and background; materials and methodology; findings and discussion; and conclusion. The following section details the materials and methods applied in this study, including the sources of literature, the selection of materials, data extraction and analysis processes involved. Subsequently, a section illustrates findings and discussion. Prior to the conclusion, a section analyzes the strengths and weaknesses of serious gaming and DGBL applications in higher education based on available studies towards identifing research gaps. The last section concludes the overall review and recommend possible directions and scopes for future research. Therefore, the results of this systematic review could draw the attention and understanding of more researchers about the strengths and weaknesses of the DGBL in the context of the educational subjects. This paper contributes to disciplinary and institutional debates on integrating serious gaming and DGBL in higher education.

GENERALIZATION OF THE MAIN STATEMENTS

The aim of this study is to analyse the current state of research and identify trends and research gaps for studies on the use of serious gaming/DGBL in higher education. The study will focus on synthesizing the applications of DGBL in different disciplines of higher education and identifying gaps in the literature from 2013-2022. To achieve this, the study investigates the countries, serious games genre, years, and educational subjects in higher education that have been the focus of DGBL research. It also observes the research methods used and review the research findings towards identifying gaps, and highlight the strengths of the literature on DGBL in higher education. The following details the eligibility criteria, inclusion and exclusion criteria, sources of materials and information, selection process, and data extraction and analysis.

3.1 Eligibility Criteria

The author used the PRISMA (2020) reporting guidelines to ensure the review is transparent, complete, and accurate. Papers published between 2011 and 2021 were searched for the review.

The keywords including "subject education" or "higher education" and "serious games" or "DGBL" were used to filter published articles available at three databases (i.e. Web of Science, SCOPUS, and Google Scholar). Through this filtering process, the author managed to retrieve a total of 211 articles, which were then being further screened based on inclusion and exclusion criteria.

2.1.1 Inclusion Criteria and Exclusion Criteria

The inclusion criteria include articles that were published in English; had an abstract; used digital games in the study or experiment; included at least one comparison of a serious game with a non-game condition; and focused only on topics with disciplinary or educational relevance. Meanwhile, the exclusion criteria include single case studies; reviews of any kind; dissertations or theses; opinions or discussion papers; articles without discipline/subject; participants not in higher education; gamification research; use of other educational tools or techniques; non-digital games; articles not in English; and those that were not directly relevant. After applying the inclusion and exclusion criteria, the author obtained 16 articles for data extraction and analysis (see Figure 1).

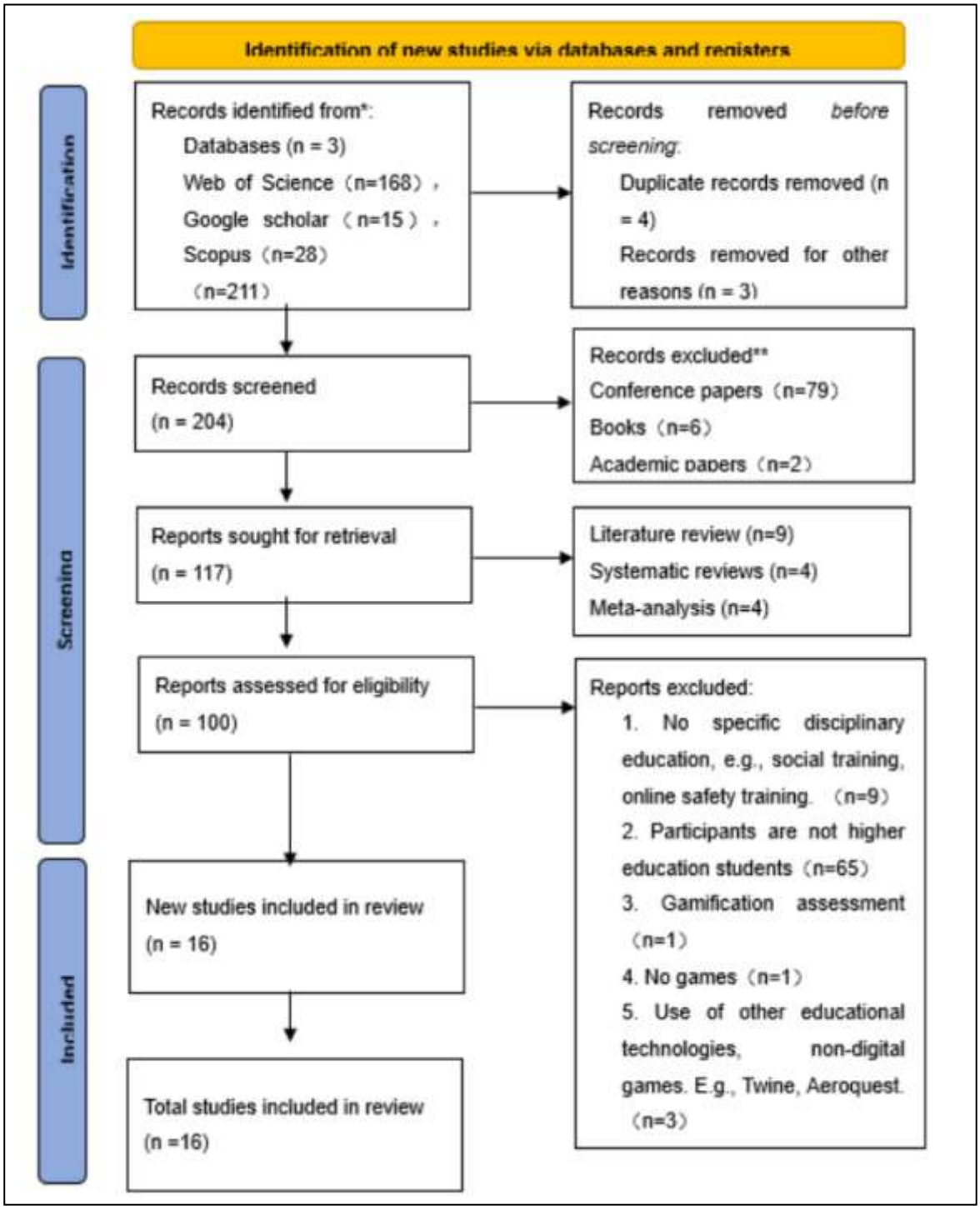


Figure 1. Flowchart of the selected sample articles based on PRISMA 2020

3.2 Data Extraction and Data Analysis

The data were extracted from Google Scholar, Web of Science, and SCOPUS. The articles were screened based on their titles, abstracts, and content. After eliminating duplicates and

irrelevant articles, the author examined the discipline of the remaining articles in relation to the educational level of the researched samples through the article abstracts. The author attempted to find high-quality research articles for selection of studies about application of serious games and DGBL in higher educational subjects. The data were analysed to conclude the development and trend of the said research field based on currently available studies.

3.2.1 Data Extraction Process

For the data extraction process, a thorough and meticulous review on all studies that met the required specific criteria was carried out. To improve the existing classification framework for serious games, researcher seeks to modify framework proposed by Connolly et al., (2012) for study on digital games in education, to better suit the focus of this paper. The modified or revised framework emphasizes the use of serious games in higher education and focuses on specific disciplines and research methods. Due to the fragmented and inconsistent nature of the literature on gaming/DGBL applications in higher education, researcher combined studies on subject of teaching and higher education into one category. The final filtered studies were assessed based on various characteristics, including research design instruments, sample characteristics, types of games, disciplines, assessment methods, types of analysis, key findings, and limitations.

3.3 Data Synthesis & Analysis

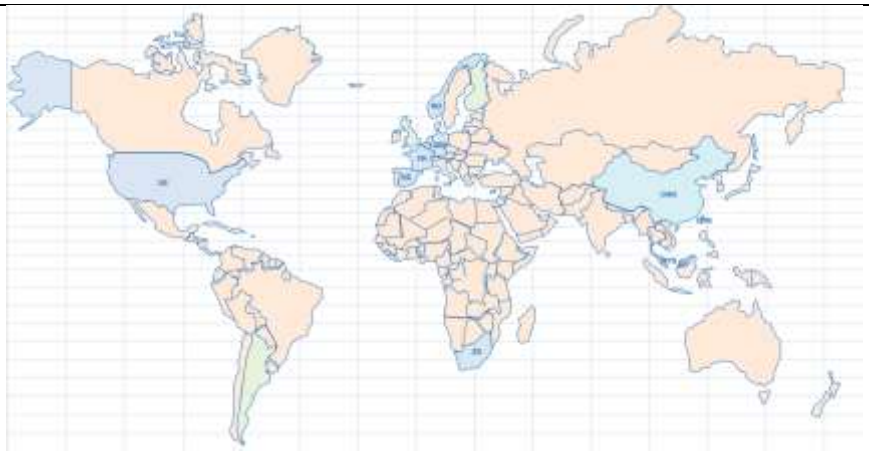
For the data synthesis and analysis phase, meta-analysis seems not a feasible option due to the diversity of DGBL outcomes in higher education and the specific objectives of review. Instead, a narrative synthesis approach that involved summarizing and interpreting the data in a textual format was adopted. This method was deemed appropriate for studies in accordance with Greenhalgh et al., (2005) and Popay et al., (2006). The analysis aimed to determine the current status and outcomes of serious games/ DGBL in higher education through thematic analysis using classification of themes (and sub-themes) as sorted by Connolly et al., (2012) and Boyle et al., (2016). Both scholar groups advocated narrative reviews to capture the diversity of research outcomes.

To analysed the identified articles, qualitative content analysis techniques applied to develop a coding scheme that included the main category, subcategories, and several related themes. Researcher examined different perspectives, including study topics, disciplines, research method design, game types, and research data analysis. Additionally, mixed methods assessment tool developed by Hong et al., (2018) were adopted to assess the items/studies/records for each study.

DISCUSSION

4.1 Countries, Years, Disciplines and Samples/ Participants

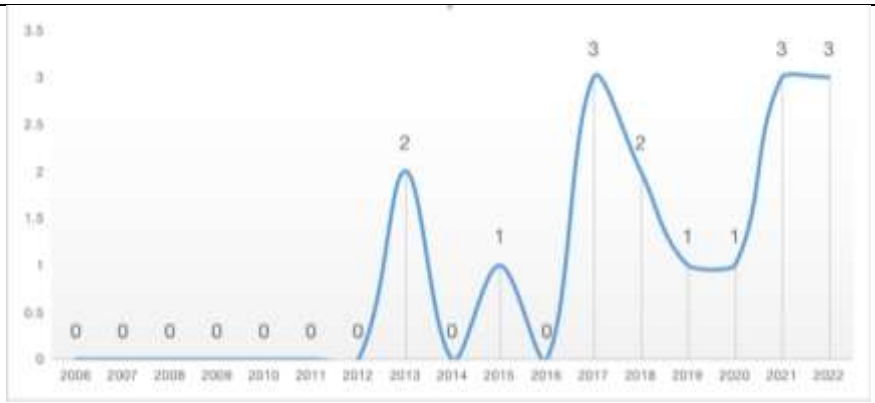
Based on the data analysis, the researchers discovered findings about the geographic distribution of the studies. After excluding the meta-analysis and review studies, the 43.75% of the studies found were conducted in Europe, 37.5% in Southeast Asia,6.25% in Africa and 6.25% in the North America (USA). This observation indicates that the majority of articles about studies on higher educational digital games came from Europe and Southeast Asia (See Figure 2). It reflects that it is one of the subject matter of interest among scholars around the world.



MYS	SG	TW	ZA	ES	FR	GER	NO	US	Total

Figure 2. Distribution of research in different Countries

According to this review, the earliest published article about research on DGBL was in 1999. This marked the formal introduction of the term 'DGBL' into academia at the first International Conference on Digital Games for Learning (Squire, 2005). The Woodrow Wilson International Center for Scholars launched the Serious Games Initiative (2002) to explore the potential of games to solve real-world problems (Zyda, 2005). However, when focus only on DGBL in higher education, there are 2 published articles about research on DGBL application in higher education in 2013. That followed by 3 articles in 2017, 3 articles in 2021 and 3 articles in 2022. These observations suggest that the active academic studies on the application of DGBL and serious games in higher education were taken place only after year 2013. Therefore, the researcher suggests that the wide adoption or application of DGBL in higher academic education is happened relatively late (See Figure 3).



2013	2015	2017	2018	2019	2020	2021	2022
2	1	3	2	1	1	3	3

Figure 3. Publication years of articles

Hussein et al., (2019) claimed in their study that there is a growing interest in the use of DGBL in basic science education. Also, when examining the disciplines in DGBL that use game-based learning, they found that the plants subjects were the most popular subjects in basic science disciplines using DGBL. However, this review which focused on higher education found no study on basic science or plants subject. Yet, there are 3 studies in the discipline of health and medicine. Games such as StikkApp and ASTRA were used several times for teaching medicine and health courses (Frøland et al., 2022; Frøland et al., 2020; Sáiz-Manzanares, 2021). For medical-related disciplines, it is crucial to understand the procedural elements (Nestel & Tierney, 2007) and gain knowledge through observation, rehearsal, discussion (White et al., 2020), experimental design, data analysis, presentation skills (Belda-Medina & Calvo-Ferrer, 2022), and experiential procedures (Frøland et al., 2022). These relevantly reflect the involvement of experiential learning process where serious games could play a role in providing relevant experiential learning. Nevertheless, other fields such as computing, management, technology, investment, and biology seem have not actively explored application of serious games. Instead, it is interesting to note that 3 educational games were used in teaching English as a second language (Belda-Medina & Calvo-Ferrer, 2022); and 2 serious games were used in teaching management subjects(Yang,2015). A study comparing games for two different disciplines (i.e. management and medicine) has identified the behaviour and attitudes of participants (Janakiraman et al., 2021). This observation suggests that there may be more options for educators to use DGBL apps to instruct students in language or English. Also, analysis found a total of 20 games were used across 16 studies in 9 different disciplines. This observation suggests that the selection of games in the discipline is a topic for discussion (see Table 1). These findings suggests that there is still plenty of possibilities to apply DGBL in

higher education to support different fields of learning purposes. The researchers suggest that the art discipline, which is the core discipline for developing creativity and innovation through learning about aesthetics and expression, should also explore the application of DGBL.

Table 1 Summary of Disciplines using games in higher education

No.	Name of Articles	Number	Percentage of Disciplines (%)
1	Technology	(n=3)	18.7%
2	Medicine	(n=3)	18.7%
3	Management	(n=2)	12.5%
4	Computer	(n=2)	12.5 %
5	Manufacturing	(n=2)	12.5%
6	Language	(n=1)	0.06%
7	Information	(n=1)	0.06%
8	Physics	(n=1)	0.06%
9	Financial Management	(n=1)	0.06%

Among the groups of samples or participants featured across 16 articles, 2 cases studied vocational students (Yang, 2015; Roodt & Ryklief, 2022), and two studies look into college students (Segaran et al., 2021; Chang et al., 2018). The remaining 12 studies (i.e., 75% of the cases) investigated university students. This reflects relatively little researches on vocational and college students. Evidently, there is a research gap focusing on college and vocational students (Table 2).

Table 2 Researched Participants/ Samples

Type of Participants/ Samples	No. of studies	Percentage
Vocational students	n=2	12.5%
College students	n=2	12.5%
University students	n=12	75%

Digital games may be more suitable for tertiary education students because they focus more on skills training and may help develop practical skills. Furthermore, the solidified thinking that comes with practical skills could be improved again through the 'certain characteristics' of digital games.

4.2 Digital games in higher education

The research categorizes the games used in higher education based on Gros (2007) classification of game genres and Zyda's (2005) definition of serious games. Simulation games (5 studies) and role-playing games (RPGs) (7 studies) are rather popularly adopted for real learning environments, for example, in health sciences, manufacturing and biology (Vlachopoulos & Makri, 2017) (See Table 3).

Table 3 Classification of games by form, title, genre & play settings/platform

	Researcher	Game form	Game title	Game genre	Play Settings/ Platform
1	Vila (2017)	2D	Fistful of dollars	Role-playing Game (RPG)	PC
2	Maraffi (2017)	2D	GeoQuest	RPG	PC Smartphones Tablets

3	Erhel (2013)	2D	ASTRA	Simulation	PC
4	Perini (2018)	2D	The Life Cycle Assessment (LCA) Game	Serious game/RPG	Laptop
5	Frøland (2022)	2D	StikkApp	Serious game	Online
6	Belda-Medina (2022)	3D	Funland	Strategies	PC
		2D	Land of Fantasy	Strategies	PC
		3D	Miitopia	RPG	Switch
7	Guo (2017)	3D	Information literacy (IL) game.	RPG	PC
8	Höyng (2022)	2D	A team-based business simulation game	Simulation	PC
9	Chang (2018)	3D	3D multimedia	RPG	PC
10	Woo (2014)	2D	OSF-CAM	Serious game	Online game
11	Segaran (2021)	2D	Color Travel	Serious game	PC
12	Roodt (2022)	2D	Millionaire Programmer	Simulation	PC
13	Wu (2020)	2D	SURGE	Simulation	PC
14	Sáiz-Manzanares (2021)	2D	UBUMonitor Application	Serious game	PC
15	Janakiraman (2021)	2D	EnerCities	Simulation	PC
		3D	The Arm Surgery game	Serious game	PC
16	Yang (2015)	2D	Chief Executive Officer	RPG	PC
		2D	Capitalism 2	RPG	PC

Researchers suggest that the RPGs and simulation games could help students understand knowledge and skills related to basic science, technology, and health & medicine (Janakiraman et al., 2021; Saiz-Manzanares et al., 2021; Hussein et al., 2019).

According to Piaget's (1951) description of imitation and assimilation theory, assimilation and adaptation are the ultimate categories of intelligent adaptation, with imitation and play being formulated as special types of relationships between adaptation and assimilation. When adaptation to external reality (virtual environment) governs assimilation (participant behaviour), a state exists that Piaget called imitation. A review by Vlachopoulos and Makri (2017) claims that simulations provide students the opportunity to observe the outcomes of their actions, take responsibility for decision-making via problem-solving competencies, and lead to a more active. This explaining why the simulations and role-playing games (RPGs) has been popularly applied, as simulations and RPGs better influencing activity of intelligence. However, while simulations and RPGs are considered the most common type of educational digital games, they may not be suitable for all subjects or learning objectives. Therefore, there is a need to explore other types of games and their potential applications in higher education.

Majority of the studies (13 studies) chose educational games that were not specifically developed for the curriculum. Findings show existing commercial games were used as tools for the intervention. Only 3 studies discussing own developed and designed games for testing and evaluation. With the lack of evaluation on the application, in a way this may suggests inconsistencies in applying the suitable or matching digital games for the learning of the

respective knowledge in higher education. For example, 'The SURGE game' which was developed based on a senior high school textbook was applied as sample game for an investigation on university students' learning of Physics (Wu,2020). The inappropriate intervention using unsuitable game in this particular research may not effectively generate reflective findings to evaluate the effectiveness of DGBL/ serious games.

The analysis of the DGBL environment is consistent with Connolly et al., (2012) who found that computers still the most popular platform. Majority (14) studies found that personal computers are still the preferred platform for playing serious games. Most studied were conducted in classroom or with computer lab settings under the supervision of teachers, research teams or both. Meanwhile observations of the laboratory environment and laboratory equipment were notably absent from across studies in this review. The impact of the computer lab environment and equipment (hardware) used for gameplay was not being studied. The cost of maintaining and upgrading the hardware or infrastructure greatly limit the ability of schools to integrate games into education (De Freitas, 2006 Klopfer et al., 2009). Meanwhile, there is still a lack of adaptive exploration of the flexibility of manipulative tools under DGBL research. Therefore, research about the adaptive assessment on updating and iteration of the games is also important to ensure quality and effectiveness of DGBL.

In total, 20 digital games were found in the 16 studies. One of the studies used 3 different digital games to teach English (Belda-Media & Calvo-Ferrer, 2022). A study on management subject used 2 digital games to analyse learning and related skills. Another study used games from 2 different disciplines to compare students' learning behaviours and attitudes (Janakiraman et al., 2021).3 studies research self-designed digital games (Segaran et al., 2021; Saiz-Manzanares et al., 2021; Chang et al., 2018) (See Table 4). In terms of intervention-based learning environments through games, most of the studies were done in classrooms or in school computer labs. One study claimed that the experiments could be conducted in both classroom and non-classroom settings (Maraffi et al., 2017).

Table 4 Researcher, discipline, game title, mode of existence, research method, context of use

Researcher	Discipline/ Subject	Game title	Existing Games/ Self-designed Games	Research Method	In class/out of class
Vila (2017)	Financial Management	Fistful of dollars	Existing Games	Experimental	In class
Maraffi (2017)	Technology	GeoQuest	Existing Games	Experimental	In class
Erhel (2013)	Medical	ASTRA	Existing Games	Quasi-experiments	In class
Perini (2018)	Manufacturing	The Life Cycle Assessment (LCA) Game	Existing Games	Quasi-experiments	In class
Frøland (2022)	Medical	StikkApp	Existing Games	Quasi-experiments	In class
Belda-Medina (2022)	Language	1.Funland 2.Land of Fantasy 3.Miitopia	Existing Games Existing Games	Experimental	In class

			Existing Games		
Guo (2017)	Information	Library escape	Existing Games	Experimental	In class
Höyng (2022)	Management	A team-based business simulation game	Existing Games	Online survey	In class
Chang (2018)	Technology	Breakfast time	Design Games	Experimental	In class
Woo (2014)	Manufacturing	Computer-Aided Manufacturing	Existing Games	Experimental	In class
Segaran (2021)	Computer	Color Travel	Design Games	Quasi-experiments	In class
Roodt (2022)	Computer	Millionaire Programmer	Existing Games	Quasi-experiments	In class
Wu (2020)	Physics material	The SURGE game	Existing Games	Quasi-experiments	In class
Sáiz-Manzanares (2021)	Medicine	UBUMonitor	Design Games	Experimental	In class
Janakiraman (2021)	Technology	1.The Ener Cities game 2.The Arm Surgery game	Existing Games Existing Games	Quasi-experiments	In class
Yang (2015)	Management	1.Virtual CEOs 2.Capitalism 2	Existing Games Existing Games	Quasi-experiments	In class

4.3 Learning Outcomes

Most of the studies (14 articles) focused on the fact that games could help with learning and the acquisition of knowledge. Meanwhile, none of these studies reported the application of games for learning art knowledge or skills. Majority of these studies used games that were suitable for single player without require teamwork or cooperation. However, 1 study investigates participants of different ages to compare the efficiency of learning through games (Belda-Medina & Calvo-Ferrer,2022), and another study used different games from different disciplines to discuss students' behaviour and attitudes in games environment (Janakiraman, 2021).

In terms of the theory, almost all papers in this review reported Prensky's (2007) DGBL theory. The majority (15 articles) of the studies reported positive results. Meanwhile, the existing researches acknowledges the role and responsibilities of teachers in DBGL process. However, in this review, the researcher found no further specific discussion about the teachers' involvement.

4.4 Experimental methods

In the review of research methods, 15 studies used experimental (8) or quasi-experimental (7) research methods. One study used quantitative survey (Hoyng, 2022). However, the author acknowledges that experiments will be conducted in subsequent study. Among the 15 studies with experimental and quasi-experimental designs, 11 of them were designed with experimental and control groups. All reported positive findings. The other 4 studies that were not divided into controlled groups and experimental groups, demanded all participants to experience DGBL intervention (Janakiraman et al., 2021; Woo, 2014; Guo et al., 2017; Vila et al., 2017). Majority of the studies (5 studies) comparing the efficiency of traditional learning and DGBL.

Furthermore, in reviewing the research design, the majority of experimental studies (10 studies) still used quantitative approach and other 6 studies used a mixed research approach. None of the existing studies reviewed applied qualitative approach (See Table 5 & Table 6). That's the major research gap that needs to be addressed in future research. Although scholars discuss DGBL from different research approaches, there is still a lack of case studies or grounded theory studies within the fields or disciplines of higher education.

Table 5 Research Design

Research Approaches	Number of Article	Percentage
Mixed method	n=6	37.5%
Quantitative Approach	n=10	62.5%
Qualitative Approach	n=0	0.00%

Table 6 Research Methods

Research Methods	Number of Article	Percentage（%）
Experimental	n=7	43%
Quasi-experiments	n=8	50%
Survey	n=1	0.06%

There is a lack of research exploring multidimensional thematic analysis on application of digital games to facilitate higher educational programs. Based on this review, only one of the 16 studies involved interviews with teachers and students following the experimental intervention. This review attempts to adapt the multidimensional framework proposed by Connolly et al (2012). The utilization of the multidimensional framework could help to sort out detailed and specific information from individual papers about the subjects or topics of interest (see Table 7). This is favourable for listing research outcomes highlighted in each article, such as motivation, cognition, attitude, game appeal, engagement, structure, perceived usefulness, learning process, methods and strategies, enjoyment/preference, flow psychological state, load in DGBL, performance, affective, etc.

Table 7. Application of a multidimensional framework in existing studies

Researchers/ Scholars/Year	Target Participants	Discipline	Digital game	Experimental Description	Research outcomes
Carenys,Moya, & Vila.(2017)	Undergraduate students	Financial Management	Fistful of dollars	1. No Control group 2. No random 3. All participate in game interventions	1. Game attributes 2. Motivation 3. Learning outcomes
Maraffi, Sacerdoti & Paris.(2017)	Undergraduate students	Senior-level technical communication	GeoQuest Vesuvius	1. Control group for participants of different ages 2. No random 3. Compare the efficiency of using DGBL at different ages.	1. Enhance engagement 2. Acquisition skills 3. Education outcomes.
Erhel & Jamet.(2013)	universities students	Medical	ASTRA	1. Random. 2. The experimental group is playing the game 3. Control group: variables in the game	1. Motivation 2. Learning processes
Perini,Luglietti,Margoudi, Oliveira & Taisch. (2018)	industrial engineering graduate	Manufacturing Education	The Life Cycle Assessment (LCA) Game	1. Experimental group: playing games 2. Control group: traditional class	1.Procedural Knowledge 2. usability & enjoyment 3. Other motivational effects dimensions
Frøland, Heldal, Braseth, Nygård, Sjøholt & Ersvær. (2022)	universities students	Medical Laboratory Technology Phlebotomy course	Stikk App	1. Random. 2. Experimental group: playing the game 3. Control group: traditional class. 4. Duration of intervention: 5 months	1. Learning effect 2. Motivation 3. Preferences
Belda-Medina & Calvo-Ferrer.(2022)	undergraduate students	Language Learning	1. Funland 2. Land of Fantasy 3. Miitopia	1. Teacher Trainees teach children English	1. Knowledge 2. Attitudes

				2. No randomisation of Teacher Trainees and children learning English are randomly assigned. 3. Each group for teaching children using game class	
Guo, Goh & Luyt.(2017)	College students	information literacy	Information literacy (IL) game.	1. All participated in the game intervention (n=150) 2. Convenience sampling. 3. No control group.	1. motivation 2. enjoyment 3. perceived usefulness
Höyng.(2022)	universities students	management and strategy	A team-based business simulation game		1. Gameful experience 2. Perceived instructional support 3. Group engagement 4. Flow
Chang, Warden, Liang & Lin.(2018)	College students	General education course titled Life and Technology.	1. 3D multimedia 2. video 3. interactive Flash activities	1. Control group: computer-based learning 2. Experimental group: game-based learning 3. Two classes were used that Participants were not randomly assigned	1. Achievement 2. Flow 3. cognitive 4. psychological state 5. load

Woo.(2014)	university students	CAM course	Operating a Small Factory in Computer-Aided Manufacturing	1. All students participate in the intervention: games class. 2. No control group.	1. Motivation 2. Performance 3. Cognitive & skill
Segaran,Mohamad Ali & Hoe.(2021)	College students	Computer Graphics course	Colour Travel	1. There are groups 2. To comparing students' arousal level and valence level	1. students' arousal of state 2. students' the valence.
Roodt & Ryklief.(2022)	Vocational Students	computer programming	Millionaire Programmer	1. Randomly assigned participants 2. Experimental group: Games class 3. Control group: Traditional class	1. Academic achievement 2. Motivation
Wu, Tzeng & Huang.(2020)	University Students	Physics material	The SURGE game	1. Randomly assigned participants (n=32) 2. Experimental group: game class 3. Control group: e-learning class	1. Learning method, 2. Attention, 3. Affective experience 4. Cognitive load, 5. Academic achievement
Sáiz-Manzanares, Martin, Alonso-Martínez & Almeida.(2021)	University Students	Nursing (ND) and Occupational therapy (OTD)	UBU Monitor (Universidad de Burgos, Burgos, Spain)	1. Participants were not randomly assigned. 2. Year 1: e-learning class 3. Year 2: Digital game class 4. No control group.	Learning Management System （LMS） 1. Meta cognitive 2. Strategies 3. Learning outcomes

Janakiraman, Watson, Watson & Newby.(2021)	Undergraduate Students	Educational technology course（Urban Planning）	The EnerCities game	1. The quantitative part is quasi-experimental, but not randomly assigned 2. One group of management games 3. One group of the Arm Surgery game	Cognitive 1. Affective 2. Behaviour 3. Social learning
Yang.(2015)	vocational students	Store Planning and Management	Virtual CEOs 1. Chief Executive Officer 2. Capitalism 2	1. Group 1: Other technical equipment classes 2. Group 2: Games classes	1. Thinking skills a. creative thinking, b. critical thinking, c. problem solving. 2. Achievement

4.5 Results of Application of DGBL in Higher Education

In terms of results of application of DGBL in higher education, the researchers thematically grouped the consequences mentioned across the 16 studies found. 11 out of 16 studies (68.8%) reviewed were focusing on engagement. However, 43.8% of studies focused on learning outcomes; 43.5% studies focused on learning achievement ;43.5%studies focused on immersion and 43.5% studies focused on digital game. However, these research outcomes do not uncover areas of concern for the researchers. Therefore, the researcher subsequently collated the frequency of these codes. The study found that the most frequently mentioned application results or impacts across the 16 articles were learning achievement and engagement, which were highlighted in 12 articles (46.2%). The next popular result was immersion, which was mentioned in 11 articles (42.3%), while the third popular result was learning outcomes (mentioned in 9 articles, 34.6%), and finally the code 'Gameplay' was mentioned in 5 articles (19.5%).

As Downes (2005) claimed, more researchers are exploring how students learn rather than focus on e-learning content. Therefore, many researchers shifted to focus on DGBL. In line with previous observations, more researchers are focusing on learning engagement and achievement in DGBL. Although DGBL and e-learning are both based on digital systems, DGBL does not cover the properties of e-learning. However, across different DGBL applications, the quality and capacity of this learning approach need to be investigated. This review confirms that DGBL contributes to learning outcomes factors, including learning engagement, learning outcomes, learning achievement, immersion and gameplay. Overall, the current findings convinced promising application of DGBL in higher education. Many studies

reporting positive outcomes in various areas. However, there is still a research gap focusing on the quality and capacity of DGBL (see Table 8).

Table 8 Researched Factors in DGBL

Sub-themes	Factors	Article	Percentage (%)	No. of Factors Mentioned	Percentage （%）
Learning outcomes	-Effectiveness -Acquire knowledge & skill -Thinking skills	7	43.8%	9	34.6%
Learning Achievement	-Cognitive -Load -Psychological state -Social learning	7	43.8%	12	46.2%
Engagement	-Learning process, -Learning methods, -Learning strategies -Motivation Performance	11	68.8%	12	46.2%
Gameplay	-Attitude -Game experience -Behaviour	7	43.8%	5	19.2%
Immersion	-Enjoyment -Affective -Perceived usefulness -Flow -Attention	7	43.8%	11	42.3%
		N=16		Total No. of Factors =26	

5. CONCLUSION

In conclusion, this study has provided a comprehensive review of the literature that analyzing the use of digital games for learning in higher education. The review followed the PRISMA 2020 guidelines, to ensure consistent and systematic filtering process for literature review. The research found a concentration of studies on digital games in health and medicine, technology, industry, computers, information, management, languages, and physics. There was no exploration of digital games in the arts curriculum, which indicating a significant gap in this field. Meanwhile, the researcher found a lack of research focusing on the tertiary educational levels, such as colleges and vocational schools. Future research should explore areas beyond

understanding of the learning content and practical skill. For example, the acquisition of 'soft skills', the exploration of other types of games, the learning and professional dispositions developed in games, and the link between interest in games and interest in learning shall be further researched. Additionally, future research should compare digital games with other educational approaches, such as flipped classrooms or VR classrooms, to assess their impact on student learning (Pashiler et al., 2008). The limitations mentioned might affect the generalizability of the findings. Finally, due to the digital nature of digital educational games, researcher could explore and discuss equity in education.

In summary, this study highlighted the potential benefits of digital games for learning in higher education while acknowledging the gaps in the literature and limitations of the study. Further research in this field will contribute to evidence-based decision-making and help develop effective strategies for integrating digital games into higher education. In conclusion, DGBL has great potential for improving higher education. However, the design and implementation of DGBL require careful consideration of the learning objectives, the characteristics of the learners, and the context of use. Therefore, it is important for educators and researchers to collaborate to develop high-quality educational games that can effectively support student learning and enhance the educational experience.

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