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The use of Digital Game-Based Learning (DGBL) in teachers' training: a scoping review

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Taking care of teachers' competencies is essential to determine a satisfactory level of quality in teaching, with a crucial impact on the proper functioning of educational services. In order to be effective, this training must consider the most recent developments in the field of technology-enhanced learning, such as Digital Game-Based Learning (DGBL). Although research in the educational field has shown that DGBL enhances learning processes, promoting learning by doing and cooperative learning as well, with all their positive effects, there is still a paucity of studies on the subject; hence, the intrinsic reason for the present investigation. This review aims to fill this gap, analyzing studies that explore DGBL for teacher training and/or teacher attitude toward using DGBL in their professional activity. We searched the following bibliographic databases: Scopus, ERIC, and Web of Science. After an accurate screening, 20 papers have been selected and included. Main results returned a clear framework of what the current literature presents as effective DGBL training for teachers and pre-service teachers and of facilitators and barriers that impact teachers' attitudes toward the use of DGBL at school.

KEYWORDS

Digital Game-Based Learning (DGBL), teachers, teachers training, serious games, digital skills, digital competencies

1. Introduction

The role of teachers finds itself in a moment of profound re-examination. The traditional model of teaching is placed under the lens of innovation, considering the impact that digital technologies and contemporary media bring in everyday life. Unexpected challenges and still underexplored possibilities are included in the current reflections of educational psychologists, pedagogists, and philosophers of education, attempting to capture tools, models, and practices that can "tune" teaching action to the communicative and informational dynamics of the 21st century, with a specific focus on digital media (Limone, 2021; Rahmatullah et al., 2022). On the one hand, teaching cannot fail to keep some of its indispensable features, which have now been proclaimed by years of pedagogical reflections and legislative regulations: the promotion of intrinsic motivation and a sense of self-efficacy in students, who experience an inclusive environment that welcomes diversity, annihilates any stigma, encouraging the autonomous development of life skills (Kunter et al., 2013; Kiefer et al., 2015; Bailey et al., 2016). On the other hand, the teacher dimension had to

face the recent challenges proposed to the world of education: the abrupt transformation of the way information is transmitted and perceived, as well as the exponential increase in the amount of data available to the user-learner or the dissemination and scientific validation of student-centered and experience-based learning theories, whereby the student is finally placed at the center of cognitive processes (e.g., constructionism, which has its roots in Dewey's thought and is declined through "learning by doing" or "learning by constructing"; Kafai and Resnik, 1996; Schank et al., 1999). Lastly, the COVID-19 experience changed the rules: the pandemic stopped the normal execution of face-to-face teaching, forcing it to become digitized through platforms, social networks, and content-sharing apps (Paparella, 2020).

Taking care of teachers' competencies is essential to determine a satisfactory level of quality in teaching, with a crucial impact on the proper functioning of educational services. Among the tasks of universities, teacher training is undoubtedly one of the most important: according to Sun et al. (2020), it should be marked by the implementation of teachers' performances, with consequent benefits on the general readiness of students. However, to be effective, this training must consider the most recent developments in the field of technology-enhanced learning.

The profound changes in teaching caused by the COVID-19 pandemic, the identification of innovative methods to foster student-centered teaching and learning strategies, together with the increased importance of games have prompted researchers to investigate the role of Digital Game-Based Learning (DGBL) at school and in training programs (Peconio et al., 2022).

The term DGBL has been coined by Prensky (2001), and it refers to a pedagogical method or approach that integrates digital games into educational curricula as learning tools (Prensky, 2003; Van Eck, 2006, 2015). According to Van Eck (2015) there are three ways to use digital games in learning at school: involving students in designing digital games, building *ad hoc* digital games to teach students specific skills and transfer specific knowledge, and integrating commercial games in the educational curricula.

Research has shown that the use of digital games in the educational field has positive effects in facilitating students' learning (Guarini et al., 2022; Peconio et al., 2022), promoting social development (Kirst et al., 2022) and fostering collaborative and cooperation skills (Grudpan et al., 2022).

1.1. DGBL, serious games and learning

According to the literature on the protective role that DGBL has on teaching and learning processes (Lei et al., 2022), teachers' training can be implemented by game-technology, as it is linked to the development of digital skills and motivation in learning. Research has shown that different mechanisms foster learning in games (Adams, 2014; Daoudi, 2022). First of all, behavioral mechanisms, such as operant conditioning, reinforcement (e.g., achieving tasks or levels, gaining tokens, or beating a high score) and punishment (e.g., losing a life or failing a level); secondly, cognitive aspects, such as the presence of problem-solving activities (use the information and contents of the game to figure out cognitive tasks), and, from an individual-constructivist perspective, of authentic and relevant activities (e.g., simulations) that foster players' situated learning (Huang et al., 2022). In addition to this, according to the self-determination theory (Deci and Ryan, 1985), videogames are able to foster learners' intrinsic motivation in terms of self-efficacy and autonomy. In these digital scenarios, which simulate reality indeed, players are able to decide and choose in autonomy the features of their character, as well as their behaviors and values. In addition to this, video games also enhance students' flow. Flow denotes an *"optimal state of motivated action, in which a person is fully immersed in a challenging task or activity while being skilled enough to master this task or activity"* (Wimmer et al., 2022). To induce flow, an activity must present clear objectives, its levels of difficulty must align with players' skills, and constant feedback must be offered (Wang et al., 2019).

Although research in the educational field has shown that DGBL enhances learning processes, promoting learning by doing and cooperative learning as well, with all its positive effects (Bado, 2022), there is still a paucity of studies on the subject; hence, the intrinsic reason for the present investigation. Studying the application of digital gaming in the educational context is an extremely fertile research activity and functional for producing innovative artifacts and methodologies for schools and universities, as recent studies demonstrate (Ade-Ojo et al., 2022). Contemporary teachers need to be up-to-date on the use of digital technologies in educational contexts. According to the European Framework DigCompEdu, teachers and educators, as role models for the next generation, should master digital competence to actively contribute to society (Caena and Redecker, 2019).

Digital Game-Based Learning could be a possible solution to train teachers using digital technologies to improve students' learning processes and the associated dimensions (e.g., students' motivation). According to the literature, DGBL has been used to improve and enhance skills in adults showing positive results (Tay et al., 2022). Specifically, DGBL fostered adult professionals learning through the use of real-world contexts (that promote the process of connecting new and prior knowledge), promoting autonomy in learning (Pannese and Carlesi, 2007; Vanduhe et al., 2020) and providing short and interactive sessions (Smith and Sanchez, 2010).

The current review aims to analyze studies that explore DGBL for the development of skills and new attitudes among teachers using DGBL in their professional activities. To the best of our knowledge, no previous literature reviews have considered the perceptions of both in-service teachers and teachers-in-training on DGBL. Results from this study can usefully supplement training programs and Teaching and Learning centers that create and provide them, shedding light on facilitators and barriers that could impact on the DGBL role in competencies and skills development and the use of DGBL itself by teachers at school.

2. Materials and methods

To identify articles studying DGBL in teacher training experiences or teachers' perceptions on the use of DGBL in educational processes, a scoping review was carried out. Scoping reviews can be described as preliminary explorations of the current scientific literature, which systematically and critically synthesize evidence on a specific scientific topic (Munn et al., 2018;

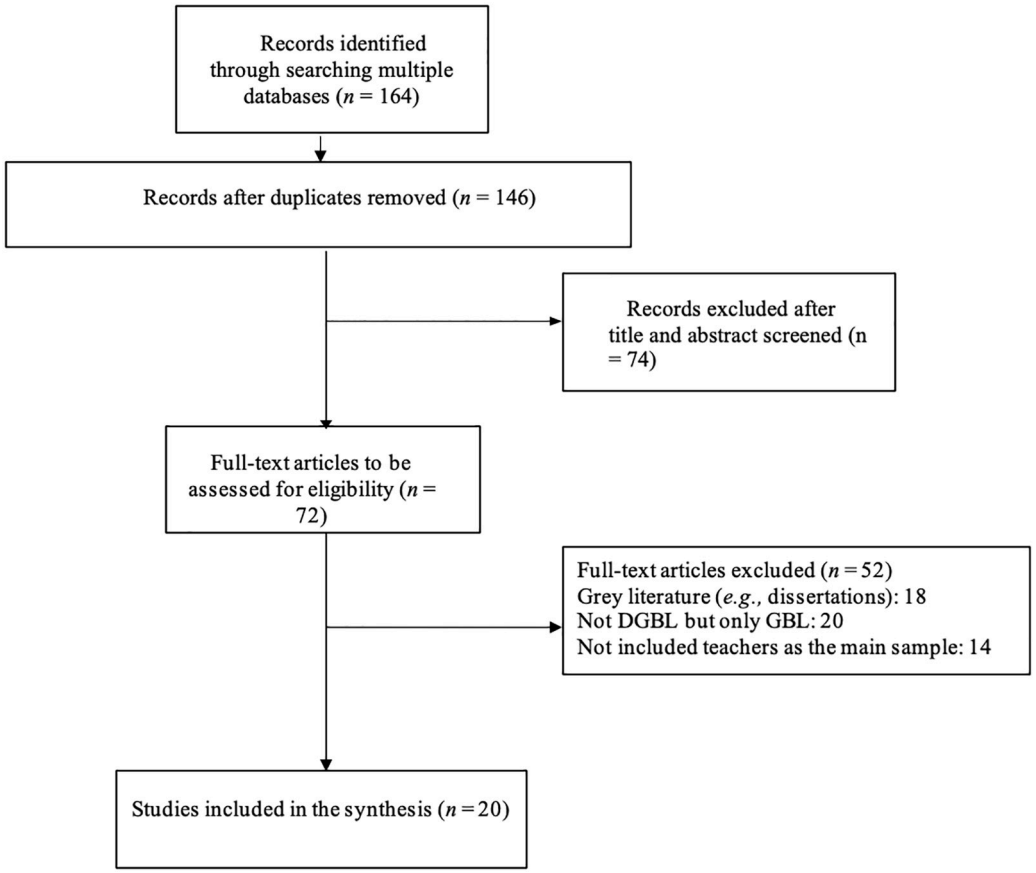

FIGURE 1
PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation.

Tricco et al., 2018). The guidelines recommended by the PRISMA Extension for Scoping Reviews (Munn et al., 2018; Tricco et al., 2018) were used.

For the literature search, the databases APA PsycInfo, Scopus, ERIC, and Web of Science were used and chosen because they include research from several scientific disciplines (e.g., education, psychology, sociology, and computer science).

The keywords "teacher* training," "teacher* initial training," "teacher* education," "teacher* initial education," "teacher* quality," "Serious game*," "game*," "game-based learning," "game based learning," were used alone and in Boolean combinations; USA and UK English variations of search terms were taken into account for the complete search strategy see the **Supplementary file**.

We adopted the following inclusion and exclusion criteria:

Inclusion criteria:

a) articles published until November 2022 (no time constrictions were applied);
b) studies published in English language;
c) studies that included teachers or pre-service teachers as the main sample of the research;
d) empirical studies (quantitative or qualitative) that analyze DGBL tools that enhance teachers' skills and competencies or teachers' perceptions on the use of DGBL tools in educational processes;
e) research protocols presenting DGBL tools that have not been implemented yet.

Exclusion criteria:

a) we excluded gray literature (materials related to organizations which are external to the traditional academic channels). Specifically, we decided to include empirical studies published in conference proceedings while excluding all the other materials, such as dissertations;
b) studies that do not include teachers or pre-service teachers as the primary sample of the research;
c) studies that do not use DGBL tools (e.g., serious games) or use only GBL tools (e.g., board games).

The review process we used to select studies is articulated in two steps. During the first step, after the removal of duplicates, two authors (BR and MdF) independently screened titles and abstracts from all the retrieved studies (n = 146). During the second step, the same reviewers independently read the full-texts of the 72 studies selected in order to evaluate their eligibility. Disagreements were solved by consulting a third author (AL). The two reviewers primarily coded 5 papers each (the papers were randomly chosen), and then they revised together the data extracted from these 10 articles. Discrepancies were solved through discussion. After this

preliminary step, the two authors partitioned the remaining articles and coded them individually.

In the final datasheet, the following information from each study was extracted: author(s), year of publication, country of origin, type of study (mixed-method, qualitative or quantitative), sample size and type of teachers involved (in-service or pre-service), type of game used and its environment, methods and procedure, measured variables, measures and statistical analyses used, and main results.

Extracted data were finally synthesized using a narrative approach in the Result section.

Figure 1 illustrates the different review process steps. Our initial search identified 146 articles; after screening for duplicates, titles, and abstracts, 72 articles were full-text read, and 20 were selected for the final review.

3. Results

The main results of this scoping review are reported in **Table 1**.

The articles included in this review were published between 2012 and 2022, with the majority of papers (8) published between 2019 and 2022. With regard to participants, the sample size varies from 13 to 410 participants; 7 studies included pre-service teachers, while the other 10 included in-service teachers. Three studies were theoretical, and they presented DBGL tools for training teachers without an empirical implementation and validation.

Concerning the type of study, 10 studies can be defined as mixed-method studies (Charlier and De Fraine, 2012; Allsop and Jessel, 2015; Karadag, 2015; Cózar-Gutiérrez and Sáez-López, 2016; Meletiou-Mavrotheris and Prodromou, 2016; Marques and Pombo, 2019; Sousa and Costa, 2020; Casanoves et al., 2022; Dashtestani, 2022; Mystakidis and Christopoulos, 2022), 3 studies are quantitative (Hsu et al., 2017; Sánchez-Mena et al., 2019; Gordillo et al., 2021), and 4 are qualitative (Pauschenwein et al., 2013; Kamışlı, 2019; Kelleci and Aksoy, 2021; Pflaumer et al., 2021).

The 20 selected studies have been divided into two major categories, according to the main aim of this scoping review: (a) studies (12) that explore teachers' attitudes and experiences related to the use of DGBL at school and (b) research (8) that investigate the efficacy of DGBL in training teachers and for fostering their skills and competencies. The three theoretical papers were included in this category, considering that the videogames they presented have been developed to train teachers and foster specific skills and competencies.

3.1. Teachers' attitudes in using DGBL at school

Concerning the studies that investigate teachers' attitudes and perceptions related to the use of DGBL at school 7 studies (Allsop and Jessel, 2015; Cózar-Gutiérrez and Sáez-López, 2016; Hsu et al., 2017; Kamışlı, 2019; Sánchez-Mena et al., 2019; Pflaumer et al., 2021; Dashtestani, 2022) presented cross-sectional surveys that measure teachers' opinions and experiences with DGBL.

On the contrary, 5 studies (Charlier and De Fraine, 2012; Pauschenwein et al., 2013; Karadag, 2015; Marques and Pombo, 2019; Mystakidis and Christopoulos, 2022) proposed training or workshops to teachers and then evaluated their attitudes toward DGBL.

For example, Karadag (2015) proposed a 12-week course on the use of GBL for teaching reading and writing skills at primary schools. In the first phase of the course (the design phase), the pre-service teachers were informed about the overall plan of the course. The pre-service teachers designed an in-class game during the second phase (the creation process). Finally, during the last phase, pre-service teachers tried integrating the designed games into the educational curriculum.

Marques and Pombo (2019) proposed a workshop that consists of four phases: (1) presentation of the EduPARK to the participants; (2) exploration of the EduPARK app in terms of collaborative game-based learning, a phase in which teachers take on the role of students; (3) teachers collaborate to plan activities and create some educational resources for students that could be integrated into the app; and (4) assessment of the activities and the workshop.

Charlier and De Fraine (2012) proposed two seminars of 4 h each. The program starts with an introductory part giving teachers a theoretical framework on GBL to foster their game literacy, and then different types of games are examined and discussed. After this phase, instructors give an assignment: design a game that you can use within an educational setting and do a real-time test of it. To complete this task, each group of students worked with an in-service teacher to create the game content in line with the actual curriculum of a secondary school class. After its creation (they had 2 months to complete the assignment), the game was implemented and tested in a 50-min lesson, involving 30 students per class.

Pauschenwein et al. (2013) proposed a training composed of an introductory workshop on innovative didactic concepts, the "learning by playing" approach and the theory of game-based learning. First, teachers studied independently for 3 weeks and completed "E-tivities" (*small online tasks that engage learners and support collaboration*). Secondly, they attended an intermediate workshop that lasted 3 weeks, during which game development tools were described, and participants shared their ideas and opinions on creating new games. The final phase of the training was online and lasted one week. During this phase, teachers created small game sequences.

While these studies presented courses that included the creation and/or a testing phase of an educational game, the one by Mystakidis and Christopoulos (2022) involved only the testing phase of a VR App based on an Escape Room format. Specifically, the game experience included three phases: (1) game tutorial in which players familiarize themselves with the VR environment and the game functions; (2) presentation of the information that players have to acquire; (3) application of the learned knowledge in four puzzles games which were organized in levels of difficulty.

Results from both the types of studies included in this section (cross-sectional survey and training programs measuring teachers' attitudes toward DGBL) find that teachers and pre-service teachers bring positive evaluations and consider DGBL an essential methodology for training teachers and future teachers. Indeed, they perceived DGBL as useful, positively impacting their dispositions and behaviors regarding the educational digital games and their implementation at school (Sánchez-Mena et al., 2019). However, despite these positive responses, teachers perceived the use of DGBL as demanding. Teachers underlined that the insufficient

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TABLE 1 Description of the studies included in the scoping review.

References, country	Aim	Type of study	Sample	Games and environment	Method and procedure	Measured variables	Measures and type of data analysis	Results
Teachers' attitudes and experiences on DGBL								
Charlier and De Fraine, 2012 Belgium	Explore if a DGBL experience can improve pre-service teachers' self-confidence for technology use, and motivates them to use DGBL for instructional purposes	Mixed	32 pre-service teachers in health science education	Educational videogames for different platforms	Workshop composed of 2 seminars of 4 h each: -1st seminar practical and theoretical background on GBL -2-months assignment -2nd seminar assessment of the assignment	-Perceptions on the value of DGBL in the teacher training program and in secondary school education; -Motivation for the use of technology and DGBL	-Questionnaire and Focus group post-intervention -Descriptive statistics and content analysis (frequencies and percentages)	-> self-confidence for technology use; -> engagement of participants in implementing DGBL
Pauschenwein et al., 2013 Austria	Teachers' perceptions about a training aimed at enhancing their skills on DGBL	Qualitative	60 teachers	Different DGBL scenarios	Training that includes a (1) Workshop on innovative didactic concepts and testing educational video games (2) a phase in which teachers design a game	Teachers' experience in attending the training	Narrative qualitative report of teachers' experiences	-Teachers are receptive to the DGBL approach, and they are highly motivated to play in their teaching or training; -It is not easy for teachers and trainers to integrate a new didactical approach into their day-today work because of a lack of time, practical experience, suitable games and tools
Karadag, 2015 Turkey	Explore pre-service teachers' perceptions regarding GBL scenarios that they have developed in a Primary Reading and Writing Instruction (PRWI) course	Mixed	189 pre-service teachers of primary school education	Different DGBL scenarios	Course of 12-weeks with 3 phases: (i) The process of the GBL design, (ii) The GBL scenario creation process, and (iii) The game-based primary reading and writing, teaching and learning processes	-Attitudes of pre-service teachers related to GBL; -Important issues and problems related to the preparation of GBL scenarios	-Questionnaires and semi-structured interviews; -Descriptive statistics and content analysis (means, frequencies and percentages)	-Positive attitudes: perceived increased skills and knowledge on how to use GBL in teaching practices; -Main concerns: feeling anxious about the possibility of failing
Allsop and Jessel, 2015 England and Italy	Teachers' perceptions on the use of computer games in primary schools in England and Italy	Mixed	89 primary Education teachers	Educational computer videogames	Cross-sectional survey	Reasons and barriers for considering using digital games in the classroom for educational purposes	-Online questionnaire + face-to-face semi-structured interviews -Descriptive statistics and content analysis (frequencies and percentages)	-Teachers in England and Italy are interested in teaching with digital games and most of them see digital games as an effective educational tool; -Not having a clear framework on game-based learning within the curriculum to guide them in the classroom, lack of subject knowledge, and not knowing how to adopt new pedagogical approaches stopped teachers from using games in teaching, and it also impacted their view of teaching with games

(Continued)

TABLE 1 (Continued)

References, country	Aim	Type of study	Sample	Games and environment	Method and procedure	Measured variables	Measures and type of data analysis	Results
Cózar-Gutiérrez and Sáez-López, 2016 Spain	Analyze opinions about emerging technologies that use gamification and GBL in initial training for future teachers	Mixed	89 pre-service primary teachers	MinecraftEdu (for computer) for the teaching of historical and artistic content	Cross-sectional survey	Level of knowledge about GBL and gamification	-Questionnaires and open questions; -Cronbach's alpha test for reliability analysis; -Descriptive statistics and differences pre- and post-intervention (Wilcoxon and sign test)	-Positive consideration of GBL as essential in training future teachers; -The training has significantly favored knowledge of, attitudes on and the application of GBL; -Teachers felt happy, motivated and enjoyed the activity, and more than 80% felt relaxed and comfortable in the process
Hsu et al., 2017 Taiwan	Explore teachers' beliefs about GBL and their relationship with demographics characteristics and pedagogical and technological knowledge	Quantitative	316 in-service elementary and middle teachers	Educational digital games	Cross-sectional survey	-Teaching beliefs about GBL (belief, confidence, and motivation); -Teachers' confidence in technological pedagogical knowledge	-Questionnaires; -Cronbach's alpha test for reliability analysis; -*t*-test and ANOVA for differences between groups; -regression analysis for investigating relationships among variables	-Teachers' GPK plays an essential role in explaining their GPCK accounting 73% of the variance explained; -Motivation, confidence and GK are the significant variables that predict GPCK; -Teachers' perceptions of GPCK did not appear to be predicted by the demographic variables; -Elementary school teachers tended to have more favorable Belief, Confidence, Motivation, GPK and GPCK; -Younger teachers whose teaching experience was less than 10 years tended to perceive higher self-efficacy in their GK, GCK, GPK and GPCK than those whose teaching experience ranged from 11 to 20 years
Sánchez-Mena et al., 2019 Spain	Explore teachers' perceived usefulness of educational video games and their attitude to use it;	Quantitative	312 teachers serving in higher education institutions	Educational videogames	Cross-sectional survey	Teachers' perceived usefulness, attitudes, ease of use and behavioral intention to use educational video games and attitude	-Questionnaires; -Reliability analysis with Cronbach's alpha and AVEs; -SEM model	-Perceived usefulness predicted attitude toward educational video games and intention to use them; -Ease of use indirectly influences attitude through perceived usefulness; -Attitude toward educational video games predicted intention to use them

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TABLE 1 (Continued)

References, country	Aim	Type of study	Sample	Games and environment	Method and procedure	Measured variables	Measures and type of data analysis	Results
Kamışlı, 2019 Cyprus	Explore primary school teachers' training needs in relation to GBL	Qualitative	410 primary school teachers	Different DGBL scenarios	Cross-sectional survey	-Inclusion of GBL in teaching practices; -Teachers' view on training related to use GBL at school	-Open-ended Questions; -Content analysis (frequencies and percentages)	-The majority of the surveyed teachers did not receive training in GBL, gamification, educational games, game-based technological tools and so forth; -The teachers reported that they want to use GBL approaches in educational activities; however, they do not use because they feel incompetent
Marques and Pombo, 2019 Portugal	Explore teachers' readiness to adopt game based mobile learning (mLearning) with AR practices after a teacher training intervention on the topic	Mixed	45 teacher trainees from several subjects and school levels	*EduPARK*: strategies for cross-subjects learning in Science (AR)	Workshop of 4 phases: (i) presentation of the EduPARK; (ii) exploration, *in loco*, of the EduPARK app for collaborative GBL with AR, as if teacher trainees were students; (iii) collaborative planning of Interaction Design and Architecture activities; (iv) evaluation of the implemented activity and of the workshop	-Opinion on EduPark and intention of using it; -Perceived ease of use of mobile technology;	-Questionnaire and focus group; -Descriptive statistics and content analysis (means, frequencies and percentages)	Positive perception of teachers on mLearning
Pflaumer et al., 2021 Germany	Teachers' attitude in using iRead at school	Qualitative	21 elementary teachers	iRead Navigo app with games for students' reading skills (on tablet)	Teachers used the app iRead Navigo with children	Feelings, expectations and actual usage of Navigo before, during and after the study	-3 Semistructured interviews for each teacher: before, 6 weeks and 12 weeks after; -Content analysis	Different profiles emerged: The 'Expert' has high digital literacy and recognizes the benefit of adaptive games; The "Willing" persona does recognize the benefit but is worried about their technical abilities; The "Skeptic" has a high digital literacy but does not recognize the benefit of adaptive games; finally, the 'Denier' has neither the digital competence nor does this persona recognize the benefit of adaptive games

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TABLE 1 (Continued)

References, country	Aim	Type of study	Sample	Games and environment	Method and procedure	Measured variables	Measures and type of data analysis	Results
Dashtestani, 2022 Iran	Explore pre-service teachers' attitudes toward DGBL in English language learning	Mixed	101 pre-service teachers	Different DGBL scenarios	Cross-sectional survey	-Attitudes of pre-service teachers toward DGBL; -Challenges of implementing DGBL	-Questionnaires and semi-structured interviews -Cronbach's alpha test for reliability analysis; Descriptive statistics and content analysis (means, frequencies, and percentages)	-Positive attitudes of pre-service teachers toward DGBL; -The lack of knowledge or competence, lack of accessibility and lack of educational digital games perceived as obstacles
Mystakidis and Christopoulos, 2022 Greece	Exploration of K-12 educators' views on the use of an educational, virtual reality-based, escape room (VRER) as an educational resource for blended learning of STEM	Mixed	41 primary and secondary education teachers	VRER *Room of Keys* (VR)	Teachers were requested to play a science-themed serious VRER Three phases: (a) the game play tutorial, (b) the presentation of the information, and (c) the knowledge application	-User experience; -Estimation of technical difficulties, and difficulty level that the escape room puzzles presented; -Received enjoyment, motivation, cognitive benefits, perceived learning, satisfaction	-Questionnaire, open-ended questions and discussion during the online debriefing session; -Descriptive statistics, correlations (Spearman's correlation and Mann–Whitney U) and content analysis	Teachers are ready and willing to adopt innovative methods and technologies that will allow them to apply active and student-centered blended learning scenarios
Use of DGBL in teachers training								
Lameras et al., 2014 England	Enhance science teachers skills in using inquiry based learning in classroom	–	–	SimAULA Educational videogame	–	–	–	–
Meletiou-Mavrotheris and Prodromou, 2016 Cyprus	Building teachers' TPACK on game enhanced mathematics learning	Mixed	13 Pre-service primary education teachers	Workshop on GBL	15 weekly 3-h sessions, (1) Phase I: Familiarization with Game Based Learning; (1) Phase II: Lesson Planning, Lesson Implementation, and Reflection	-Use of and attitudes toward using computer games in daily life and in the mathematics classroom; -Knowledge acquisition	-Open-ended pre-survey and interviews; -Classroom observations; -Evaluation reports and lesson plans; -Field notes and reflection papers; -Content analysis	-Participants had a very limited TPACK regarding games as educational tools; -Development of a more sophisticated view regarding the benefits of gaming; -Positive attitudes toward game-based mathematics learning, and strong intention to incorporate games into their future teaching practices
Sousa and Costa, 2020 Portugal	-Create conditions that allow the creation of digital games in the formal schooling contexts; promote technical and sociocultural skills in the field of digital identiti(es) management; -Assess the effectiveness of game creation in the development of Media and Information Literacy (MIL) skills	Mixed	21 teachers	Educational videogames	Training Program of 36 h on MIL	-Teachers' main motivation and expectations; -Teachers' beliefs regarding the relationship between videogames and learning and the inclusion of media education in formal schooling; -Promotion of teachers' skills development in MIL	-Open-ended questions, Questionnaires pre and post-test; -Content analysis and Wilcoxon signed rank test for pre and post differences	-Teachers recognize the pedagogical potential of videogames to engage students in learning processes; -Inclusion of media education in formal schooling context should be mandatory and framed as a transversal subject; -Game creation can be considered as an effective strategy to promote teachers' MIL skills

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TABLE 1 (Continued)

References, country	Aim	Type of study	Sample	Games and environment	Method and procedure	Measured variables	Measures and type of data analysis	Results
Kelleci and Aksoy, 2021 Turkey	Examine the experiences of teacher candidates and academics in the use of SimInClass, a game-based virtual classroom simulator	Qualitative	16 teachers senior candidates majoring in elementary school education	SimInClass, computer or mobile device simulation virtual environment	Teachers completed 16 scenarios in 14 weeks	-Users' evaluations of Technical Issues, Interface, and Content Users' attitudes and suggestions toward the SimInClass Simulation; -The Experiences of Academics in Using SimInClass Simulation as part of Teacher Training	-Focus group, one-to-one interview, observation; -Content analysis	-The simulation is perceived authentic and entertaining; -Half of the participants stated that they would like to play the SimInClass simulation again, while the other half made suggestions for improving the simulation in order for them to be able to play it again (having real life experiences, feedbacks, customizations, sounds, scrip freezing)
Sica et al., 2022 Italy	Use of digital technologies to develop processes that address to creativity: applying digital pedagogies to develop processes that are particular to creativity	–	–	DoCENT educational videogame	–	–	–	–
Gordillo et al., 2021 Spain	Investigate the effectiveness of educational video GBL for teacher training in the e-safety area	Quantitative	179 teachers	Educational video game (Flappy Birds with multiple questions)	MOOC course with educational videogame	-Acquisition of competence in the area of e-safety; -Teachers' perceptions toward the use of DGBL for the development of teacher digital competence in the area of e-safety	-Pre- and posttest questionnaires for knowledge acquisition; -Posttest questionnaires for teachers' perceptions; -Reliability analysis with Cronbach's alpha; -Wilcoxon Signed-Ranks Test for pre and post differences	-Educational video game-based learning is an effective and viable option to train teachers on issues pertaining to the e-safety area of teacher digital competence; -This new form of learning is well received by teachers
Zetzmann et al., 2021 Germany	Improve SRL knowledge and skills by linking theoretical learning input with playful learning	–	–	*Regulatia* Educational videogame	–	–	–	–
Casanoves et al., 2022 Spain and Sweden	Verify if Recal game promote pre-service teachers' learning of genetics and what characteristics of DGBL promote learning according to participants	Mixed	120 Spanish pre-service teachers and 51 Swedish preservice teachers	Educational game Recal	Pre-service teachers play with the game about 90-120 minutes during a science course	-Genetic knowledge; -Expectations regarding the learning game; -Experience of and satisfaction with the game	-Pre and post questionnaires; -Open-ended questionnaires; -Reliability analysis with Cronbach's alpha; -t-test and ANOVA for differences between groups; -Content analysis	Results of the pre- and post-intervention tests of genetic knowledge show that the Recal game can improve the genetic knowledge of participating students; -Teacher students' experiences were generally positive, and similar in both countries, indicating that the Recal game has both utility and validity

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training received on DGBL represented a relevant obstacle to implementing this methodology at school, also representing a risk factor for their self-confidence.

3.2. Use of DGBL in training programs to improve teachers' skills and competencies

Eight studies (Lameras et al., 2014; Meletiou-Mavrotheris and Prodromou, 2016; Sousa and Costa, 2020; Gordillo et al., 2021; Kelleci and Aksoy, 2021; Zetzmann et al., 2021; Casanoves et al., 2022; Sica et al., 2022) proposed training programs that used DGBL to improve and foster teachers' and pre-service teachers' skills in different fields: e-safety area (Gordillo et al., 2021), teaching skills and classroom management (Lameras et al., 2014; Kelleci and Aksoy, 2021; Zetzmann et al., 2021; Sica et al., 2022), TPACK on game-enhanced mathematics learning (Meletiou-Mavrotheris and Prodromou, 2016), Media and Information Literacy (MIL) skills (Sousa and Costa, 2020), Science and genetics (Casanoves et al., 2022).

Sousa and Costa (2020), for example, proposed a 36-h training program to foster teachers' MIL competencies. The main goal was to provide teachers with the appropriate skills to create digital games for their students, working in groups.

Gordillo et al. (2021) established a MOOC course focused on e-safety covering different topics such as digital identity, protection, use of personal data, privacy management and licensing of digital content. Kelleci and Aksoy (2021), with SimInClass, a real-life experience through a simulation app of the classroom environment. Meletiou-Mavrotheris and Prodromou (2016) proposed a two-phase workshop on DGBL to improve teachers' TPACK on DGBL applied to mathematics, while Casanoves et al. (2022) proposed an educational game that helps pre-service teachers to encounter and acquire an understanding of key genetic, engaging them in a true-to-life scientific scenario in which they play as a scientific evaluator.

Among these studies, three (Lameras et al., 2014; Zetzmann et al., 2021; Sica et al., 2022) presented educational games developed to train teachers' skills in the classroom environment; however, these tools have never been empirically validated. In their study, Sica et al. (2022) specifically presented *DoCENT*, an educational game that simulates teacher–student relationships in the classrooms, helping teachers to develop digital creative teaching and providing an interactive environment in which they can make mistakes and collaborate safely. Lameras et al. (2014), developed an educational video game, *SimAULA*, that allows teachers to enhance their skills in using inquiry-based learning while interacting with students' characters and developing educational curricula in the simulated classrooms. Finally, Zetzmann et al. (2021) developed *Regulatia*, an educational video game that fosters teachers' knowledge on self-regulated learning, using a narrative enriched with metaphors to create an immersive environment, which can promote the learning process.

The training courses implemented in these studies resulted effective in improving teachers' and pre-service teachers' skills. Furthermore, all the teachers who participated in studies in which the videogames have been implemented (Meletiou-Mavrotheris and Prodromou, 2016; Sousa and Costa, 2020; Gordillo et al., 2021; Kelleci and Aksoy, 2021; Casanoves et al., 2022) perceived DGBL as a valuable tool to use in their teaching practice.

Concerning the studies in which the educational games for teachers have not been implemented (theoretical studies; Lameras et al., 2014; Zetzmann et al., 2021; Sica et al., 2022), the authors presented the process with which they designed and developed these products. All three studies took into account pedagogical and psychological theoretical frameworks (Self-Regulated Learning, Zetzmann et al., 2021; Inquiry-Based Learning, Lameras et al., 2014; Situated Psychological Agents, Sica et al., 2022) in creating games' contents and mechanisms to provide theoretical-informed training to teachers. In addition, Sica et al. (2022) included a co-creation step in their design process, which involved 36 Italian teachers who gave feedback on the MOOC contents and the Docent serious game while the design process was ongoing. Regarding future perspectives, all the authors of the three studies highlighted the importance of initiating studies that could test the effectiveness of these educational games in improving teachers' skills and competencies. Specifically, they directed future studies using rigorous research design (e.g., randomized controlled trial) with control groups.

3.3. Methodological characteristics of the included studies

Although the studies presented very homogenous outcomes in terms of the positive effects of DGBL on learning processes and positive teachers' attitudes toward this innovative methodology, they are very heterogeneous in terms of methodological features. Many of the screened studies (Charlier and De Fraine, 2012; Allsop and Jessel, 2015; Cózar-Gutiérrez and Sáez-López, 2016; Meletiou-Mavrotheris and Prodromou, 2016; Marques and Pombo, 2019; Sousa and Costa, 2020; Kelleci and Aksoy, 2021; Pflaumer et al., 2021; Mystakidis and Christopoulos, 2022) included very small samples (<100 participants), and most of the studies presented a cross-sectional design. Only four studies (Cózar-Gutiérrez and Sáez-López, 2016; Sousa and Costa, 2020; Gordillo et al., 2021; Pflaumer et al., 2021) included a pre- and post-test research design. Measures were generally both quantitative (self-report questionnaires) and qualitative (open-ended questions, interviews, focus groups); however, the statistical analyses performed were, in most cases, item analyses (descriptive statistics reported in terms of means, frequencies, and percentages) and content analysis for the qualitative explorations.

4. Discussion

The main aim of the current study was to review the literature focused on teachers' attitudes and experiences with DGBL at school and DGBL used to train teachers and foster their skills. Specifically, this review aimed at critically analyzing the screened papers to have a clear framework of what the current literature presents as effective DGBL training for teachers and pre-service teachers and of facilitators and barriers that impact teachers' attitudes related to the use of DGBL at school.

Overall, our results showed that most teachers believe that DGBL should be included in training programs, suggesting they can use this methodology in educational contexts (e.g., Charlier and De Fraine, 2012; Pauschenwein et al., 2013; Allsop and Jessel, 2015; Karadag, 2015; Cózar-Gutiérrez and Sáez-López, 2016; Meletiou-Mavrotheris and Prodromou, 2016; Kamışlı, 2019; Sánchez-Mena et al., 2019; Sousa and Costa, 2020; Dashtestani, 2022; Mystakidis and Christopoulos, 2022). Moreover, at the end of the most of the courses and workshops proposed in the reviewed studies, participants reported that DGBL effectively improved their confidence and competencies (Charlier and De Fraine, 2012; Karadag, 2015; Cózar-Gutiérrez and Sáez-López, 2016; Sánchez-Mena et al., 2019; Casanoves et al., 2022; Mystakidis and Christopoulos, 2022) and that DGBL enhanced their abilities in building knowledge with ease, getting the content of the training in a more suitable way, and tying together theory and practice (e.g., Charlier and De Fraine, 2012; Karadag, 2015; Cózar-Gutiérrez and Sáez-López, 2016; Sánchez-Mena et al., 2019; Casanoves et al., 2022; Mystakidis and Christopoulos, 2022). According to previous literature (Sánchez-Mena et al., 2019), perceived DGBL usefulness represents the main antecedent of teachers' attitudes toward educational video games and predicts teachers' behavioral intention to use them in their teaching activities.

In addition to this, teachers perceived DGBL as a process that could foster students' positive outcomes by attracting and maintaining their attention, arousing their interest during lessons, combining fun and learning, providing feedback, and promoting motivation, problem solving, collaboration, critical thinking and creative thinking (Karadag, 2015; Mystakidis and Christopoulos, 2022). These results are in line with those founded by Bayirtepe and Tüzün (2007). In their study, indeed, these researchers found that students found GBL appealing and that they reported lower levels of perceived anxiety symptoms. Furthermore, the research of Tham and Tham (2012) with students attending university demonstrated that GBL enhanced motivation, collaborative learning, teamwork socialization, interest and participation in lessons. These results are also in line with previous research, showing that fostering critical thinking and learning skills in students can encourage the use of innovative pedagogical methods in the classroom (Dashtestani, 2022). Thus, DGBL resulted in an effective instrument to make educational curricula more "authentic", as close as possible to the daily life of students.

Even if most teachers in the screened studies reported positive outcomes in relation to DGBL, barriers and negative attitudes of teachers toward DGBL implementation emerged. For example, teachers reported difficulties in identifying games that could fit with their curricula, they perceived a lack of theoretical knowledge on GBL, and they perceived not to know how to adopt new pedagogical approaches, highlighting a lack of training in this field (e.g., Pauschenwein et al., 2013; Allsop and Jessel, 2015; Kamışlı, 2019; Dashtestani, 2022). According to previous studies (Becker, 2007; Charlier and De Fraine, 2012), the integration of digital games in teaching activities is related to higher levels of teachers' perceived self-efficacy and confidence in creating and using these games and in their personal experience of the positive effects that these games produce the educational context. Consequently, teachers training on DGBL is required.

Studies, courses, and workshops included in this review are very heterogeneous in terms of contents, design processes, research design and modalities of implementation during the training; thus, it is difficult to identify the features of educational games and training that can be defined as effective in promoting teachers' positive attitudes toward DGBL or fostering their skills. However, one characteristic that some of the reviewed programs share and highlight as effective is the use of practical sessions (e.g., Charlier and De Fraine, 2012; Pauschenwein et al., 2013; Karadag, 2015; Meletiou-Mavrotheris and Prodromou, 2016; Marques and Pombo, 2019; Kelleci and Aksoy, 2021; Pflaumer et al., 2021; Casanoves et al., 2022; Mystakidis and Christopoulos, 2022). Teachers' DGBL skills development resulted in more effective if theoretical concepts on the use of GBL were demonstrated in real-to-life classroom environments (e.g., simulations). The reviewed studies, such as the one of Charlier and De Fraine (2012), have shown that a practical approach to the course in terms of situated learning resulted in higher levels of teachers' motivation, self-confidence in using technology, and engagement in using DGBL in their classrooms.

Concerning the methodological characteristics of the included studies, several limitations emerged.

Overall, samples are very small (<100 participants) and research designs are usually cross-sectional, making it difficult to use sophisticated data analyses and, consequently, generalize the obtained results to the general population. In addition, pre- and post-interventions and longitudinal designs should be used in future research to verify long-term impact and outcomes of DGBL training on teachers' skills development.

The findings of this review should also be interpreted in light of some limitations. First, we included only English-language articles and, therefore, may have overlooked findings in other languages. Second, although we conducted an exhaustive search, some search terms may have been omitted. Third, although we screened in-depth the retrieved studies, it could be possible that some studies were overlooked. However, to the best of our knowledge, this review is the first to synthesize studies on teachers' attitudes and experiences related to the use of DGBL at school and DGBL programs that foster teacher skills training.

5. Conclusions and future perspective

In conclusion, this review highlighted critical issues that future researchers should bear in mind to enhance teachers' training outcomes and foster teachers' digital competencies related to the use of DGBL with students:

a) teachers reported that DGBL could be a useful tool to be included in their pedagogical practices (e.g., Charlier and De Fraine, 2012; Pauschenwein et al., 2013; Allsop and Jessel, 2015; Karadag, 2015; Cózar-Gutiérrez and Sáez-López, 2016; Meletiou-Mavrotheris and Prodromou, 2016; Kamışlı, 2019; Sánchez-Mena et al., 2019; Sousa and Costa, 2020; Dashtestani, 2022; Mystakidis and Christopoulos, 2022); however, training for teachers is required to help them to understand better how to include DGBL in educational practices, find games that are significant to their curricula (e.g., Pauschenwein et al., 2013; Allsop and Jessel, 2015; Kamışlı, 2019; Dashtestani, 2022) and

enhance their self-efficacy, confidence and competencies (Charlier and De Fraine, 2012; Karadag, 2015; Cózar-Gutiérrez and Sáez-López, 2016; Sánchez-Mena et al., 2019; Casanoves et al., 2022; Mystakidis and Christopoulos, 2022);

b) training course for teachers should include a testing phase to do practical experience, a very important factor that fosters learning and increases their knowledge, motivation, and self-efficacy in using DGBL at school (e.g., Charlier and De Fraine, 2012; Pauschenwein et al., 2013; Karadag, 2015; Meletiou-Mavrotheris and Prodromou, 2016; Marques and Pombo, 2019; Kelleci and Aksoy, 2021; Pflaumer et al., 2021; Casanoves et al., 2022; Mystakidis and Christopoulos, 2022);

c) reliable research designs (e.g., randomized controlled trials, pre and post-test design, longitudinal studies) are needed to outline better the role of the different training components in the effectiveness of DGBL courses and their long-lasting effects (e.g., Lameras et al., 2014; Zetzmann et al., 2021; Sica et al., 2022).

Considering the main results of this review and according to previous literature, we believe that future studies should also try to include the following aspects while testing the effectiveness of DGBL in enhancing teachers' skills and competencies:

a) should take into account the moderating role of teachers' demographic characteristics (e.g., gender, age), teachers' individual factors (e.g., teachers' proneness to digital games or their innovativeness), or characteristics of the Teaching and Learning Centers (TLCs) that provide the training, that could impact on teachers' intent to use digital games;

b) should include special education teachers. According to literature, indeed, Information and Communication Technologies (ICTs) have positive effects on teaching and learning in special education: assistive technology is essential for students with learning difficulties, helping them in delivering learning tasks and participating equally in the classroom (Puspawati and Juharoh, 2021);

in their training, they should include game design experiences for teachers to enhance their programming skills and digital competencies, also analyzing the role of design elements that impact teachers' perceived utility of digital games (An and Cao, 2017);

a) future studies could also take into account the possibility of having connections among policymakers, research institutes (e.g., universities) and schools in creating training programs. Universities, in particular, should constantly communicate with teachers, training them and giving them an active role in developing DGBL strategies. A possible tool to maintain good communication between TLCs (e.g., universities) and teachers-in-training could be creating a digital platform dedicated to DGBL on which teachers can sign during the training and access contents, and on which researchers can use to monitor teachers' progress.

Author contributions

BR, GT, MF, AL, and PL: conceptualization and writing—review and editing. BR, MF, and AL: methodology and writing—original draft preparation. GT and PL: supervision. All authors read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2023.1092022/full#supplementary-material

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