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Review

A systematic literature review of teacher scaffolding in game-based learning in primary education

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ABSTRACT

In recent years, research interest in games in education has experienced continuous growth. However, although prior reviews in this context have generally focused on providing an overview of research trends and the impact of game-based learning on education, they have failed to provide noncrucial information on teacher scaffolding strategies used in the different stages of game-based learning and its related effects on students' learning in primary education. By conducting a systematic search of databases, the current review examines recent empirical studies, ranging from 2011 to the end of March 2022, that implemented game-based learning in primary education settings. Twenty-four relevant papers were selected by deploying a four-phase PRISMA framework. This review identified different teacher scaffolding strategies that are used in teacher–student interactions during the orientation and gameplay stages, and their correlative influence on students' learning. These findings can help teachers, teacher educators, and game developers in designing and developing improved game-based learning. The requirement for more research to investigate the use of teacher scaffolding in teacher–student interactions within the game-based learning process in primary education is emphasized. Furthermore, recommendations are offered for the future implementation of teacher scaffolding in game-based learning research.

1. Introduction

Games are considered to be one of the most enjoyable and motivating activities, particularly among children and young people (Bang et al., 2023; Kordaki, 2011; McFarlane & Sakellariou, 2002; So et al., 2019). They provide people with opportunities to think about and understand complex issues and bring forth innovative ways to explore problems (Gee, 2003; Ilten-Gee & Hilliard, 2021; Lotherington & Ronda, 2009; O'Rourke et al., 2017). In this context, games that have educational objectives and contain content related to learning are considered to have the potential to make learning more fun, interesting, and effective (Bang et al., 2023; Kafai & Ching, 2001; Prensky, 2001; Tsai et al., 2020). In addition, games afford strong motivation for student engagement in learning, thus affecting their emotional, social, and cognitive development (Bang et al., 2023; Bragg, 2012; DeVries, 2002). Therefore, the increased popularity and proliferation of games have led to an extensive and growing interest in finding ways to combine them with curriculum content (Bragg, 2012; Ilten-Gee & Hilliard, 2021; Kyriakides et al., 2016).

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This systematic literature review (SLR) aims to explore how teachers scaffold students in teacher–student interactions when integrating game-based learning into primary education. In particular, this review focuses on understanding the influence of teacher scaffolding on primary school students' learning. The review begins with a brief introduction to game-based learning in primary education and the kind of teacher scaffolding that is generally applied to this educational context. This is followed by detailed descriptions of the purpose of this review and the primary research questions it seeks to address. Subsequently, Section 2 describes the process of conducting the systematic review. The results of the reviewed studies are summarized in Section 3. Finally, the review concludes with a discussion of the findings of the literature review and recommendations for future research.

1.1. Game-based learning in primary education

Following the widespread application of games in the field of education, game-based learning has drawn increasing attention (Sun et al., 2021b; Meletiou-Mavrotheris & Prodromou, 2016). According to Tang et al. (2009), game-based learning can be defined as follows:

The innovative learning approach derived from the use of computer games that possess educational value or different kinds of software applications that use games for learning and education purposes such as learning support, teaching enhancement, assessment and evaluation of learners. (p. 3).

A game's content and gameplay help students acquire knowledge and develop skills, while game activities that involve participating in problem-solving tasks and challenges provide students with a sense of achievement (Kay & Kwak, 2018; Qian & Clark, 2016; Wen, 2018). Game-based learning is based on the following five characteristics: (1) using action instead of explanation, (2) creating personal motivation and satisfaction, (3) accommodating multiple learning styles and skills, (4) reinforcing mastery of skills, and (5) providing an interactive and decision-making context (Charles & McAlister, 2004; Holland et al., 2003; Kebritchi & Hirumi, 2008). These characteristics support the integration of game-based learning into various educational settings as well as different levels of education.

Primary education (in which student ages range from 6 to 13 years old) refers to the first stage of compulsory education, which provides students with the fundamental knowledge and skills that serve as foundations for their academic careers (Sun et al., 2021a; Hainey et al., 2016). A number of studies have identified that game-based learning has many benefits for teaching and learning in primary education, especially because it is able to capture students' interests and promote their learning of basic knowledge (e.g., Sun et al., 2021b; Sun et al., 2022; Baek & Touati, 2020; Hainey et al., 2016; Hsu & Wang, 2018; Kyriakides et al., 2016). However, concerns have also been raised regarding the negative effects of games on learning (Van Eck, 2006; Wen, 2018). One such issue pertains to ensuring a suitable balance between gaming and learning activities so that students are not distracted by the game-based features and are instead encouraged to pay more attention to the learning content (Kickmeier-Rust et al., 2007; Kim et al., 2009; Van Eck, 2006). Another problem with game-based learning is that novice or inexperienced students find it difficult to apply prior knowledge to gameplay, which leads to low motivation and engagement (Chen & Law, 2016). This highlights the necessity of integrating teacher scaffolding into game-based learning, particularly in primary education, to help students develop the habit of self-regulation and build connections between game content and subject knowledge (Atmatzidou & Demetriadis, 2017; Barzilai & Blau, 2014; Chen & Law, 2016; So et al., 2019; Wen, 2018).

1.2. Scaffolding

The concept of scaffolding has received much attention in educational research for several decades (Atmatzidou & Demetriadis, 2017; Belland et al., 2013; Chen & Law, 2016; van de Pol et al., 2010). The metaphor of scaffolding was introduced by Wood et al. (1976), who defined the term as referring to tutoring or assistance that "enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted effort" (p. 90). Typically, scaffolding has been associated with Vygotsky's (1978) sociocultural theory, especially with his concept of the zone of proximal development (ZPD). According to Vygotsky's (1978) theory, learning is considered a social activity in which interaction and language play central roles. Moreover, it emphasizes that learning happens within the ZPD, which refers to the difference between what a student can do independently and what s/he can do with the help of a more knowledgeable other (van de Pol et al., 2012; Vygotsky, 1978). In the same context, Roehler and Cantlon (1997) referred to scaffolding as the support provided within a student's ZPD.

In the last few decades, "scaffolding" has often been used as a synonym for the provision of any kind of support (Mercer & Littleton, 2007; Stone, 1998). However, the support provided by scaffolding should ideally consist of three main characteristics: (1) contingency, (2) fading, and (3) transfer of responsibility (van de Pol et al., 2010). Contingency stands for the adaptive nature of scaffolding support (van de Pol & Elbers, 2013), meaning that it is the kind of support that can be adapted to or is contingent upon students' existing understandings (van de Pol et al., 2012, 2015). Moreover, this support is not permanently provided—it fades over time (van de Pol & Elbers, 2013; van de Pol et al., 2010). Finally, the ultimate goal of scaffolding is to enable students to perform tasks independently with the aim of gradually transferring responsibility for such tasks to the students (van de Pol et al., 2010, 2012). Notably, van de Pol and Elbers (2013) indicated that contingency should be viewed as "the most central characteristic of scaffolding as non-contingent fading and non-contingent transfer of responsibility can never be called scaffolding" (p. 33).

Generally, scaffolding is viewed as an interactive process that operates between the teacher and the student. It is a dynamic intervention that focuses on a student's ongoing progress. Moreover, the support provided by the teacher during scaffolding depends on the current circumstances and responses of the student (Belland et al., 2013; van de Pol et al., 2010). Hence, scaffolding does not look the same in various situations, nor is it a technique that can be implemented in all kinds of situations (Feng & Chen, 2014; Tropper et al., 2015; van de Pol et al., 2010). Therefore, it is of no surprise that scaffolding has been used in various kinds of research—for example, dyadic interaction (Wood et al., 1978), interactions between a teacher and a small group of students (Sun et al., 2022; van de Pol et al., 2014), and whole-class teaching (Sun et al., 2021b; Smit et al., 2013).

1.3. Teacher scaffolding in game-based learning

According to Van Eck (2015), the potential of game-based learning to enhance students' learning is conditional—it depends on the attributes and affordance of the games (Cai et al., 2022). As a type of affordance, teacher scaffolding is likely to facilitate student learning in game-based learning environments (Atmatzidou & Demetriadis, 2017; Kangas et al., 2017, Dukuzumuremyi & Siklander, 2018, Sun et al., 2021b; Chen & Law, 2016). Furthermore, as an interactive process operating between the teacher and students, teacher scaffolding in game-based learning may not only provide adaptive support in enabling students to solve complex tasks but also increase their motivation and engagement to continue play (Barzilai & Blau, 2014; Chen & Law, 2016; So et al., 2019).

There are multiple significant differences between the utilization of teacher scaffolding in game-based learning and in a regular classroom setting. First, the support provided by a teacher in regular classrooms generally focuses on small-group or one-to-one scaffolding (e.g., Muhonen et al., 2016; van de Pol et al., 2019). However, in game-based learning, with the exception of the approaches mentioned above, whole-class scaffolding has been one of the most prominent approaches. The objectives of whole-class scaffolding are to guide students toward understanding the topic and learning goals (Chee & Tan, 2012; Silseth, 2012), initiate the gaming session (Kangas et al., 2017, Sun et al., 2021b; Barab et al., 2010), and provide contingent support based on the current state of understanding and knowledge construction of most students (Sun et al., 2021b). Second, because of the game elements, scaffolding in game-based learning is largely visual, as opposed to being only verbal (Mayer et al., 2002). Observing students' gameplay enables the teacher to collect information about their current understanding accurately and rapidly, thus making it easier to provide tailored support that is adaptive in response to the collected diagnostic information (Hermkes et al., 2018; Mayer et al., 2002; van de Pol et al., 2014). Third, scaffolding in game-based learning positively influences student participation (Monjelat et al., 2017; Silseth, 2012). The specific activities conducted by the teacher during gameplay, such as teacher-facilitated discussions, encourage students to participate actively (Sun et al., 2021b; Silseth, 2012). Finally, scaffolding in game-based learning can help students build a link between the game and its relevance in real life. For example, Silseth (2012) found that the teacher often tries to bridge gameplay with the world outside the classroom by using the events in the game as a reflection of real-life activities.

Furthermore, the scaffolding provided by the teacher during teacher–student interactions can be viewed as a valuable resource for students' game-based learning (Silseth, 2012). Teacher–student interaction has been described as "a co-evolution of student's levels of understanding and teacher's supporting behaviour" (Hermkes et al., 2018, p. 148). During gameplay, students are allowed to identify and report their difficulties. In response, the teacher's major task is to diagnose the student's understanding and provide tailored support to address these difficulties (Chiu, 2004; Hermkes et al., 2018; van de Pol et al., 2015). Hermkes et al. (2018) considered these interactions to be part of the knowledge co-constructive process, to which "the teacher and students contribute in a distinctive way" (p. 150). While students are responsible for solving puzzles in the game to achieve a certain level of attainment, the teacher's role is to provide constructive support whenever needed (Kangas et al., 2017, Sun et al., 2021b; Hermkes et al., 2018; Silseth, 2012).

Therefore, it may be presumed that implementing teacher scaffolding in game-based learning will be beneficial to students, particularly in primary education (Atmatzidou & Demetriadis, 2017; Kangas et al., 2017, Dukuzumuremyi & Siklander, 2018, Sun et al., 2021b; Chen & Law, 2016). The teacher acts as a facilitator who directs the learning process and helps students deal with specific obstacles to acquiring the target knowledge and skills (Chuang et al., 2021; Haruehansawasin & Kiattikomol, 2018; Liu et al., 2018; Wong et al., 2017). Furthermore, an increasing amount of research has indicated that the teacher serves as a guide in game-based learning, helping students build a link between subject knowledge and game content (Sun et al., 2021b; Barzilai & Blau, 2014; Rienties et al., 2012). In addition, the teacher's encouragement has been found to have a positive effect on student emotions and persistence in learning (Barzilai & Blau, 2014; Chen & Law, 2016; So et al., 2019). Notably, the scaffolding provided by a teacher in teacher–student interactions can materialize in different ways, including asking probing questions, discussing, explaining the game and its relation to practical methods, providing immediate feedback, offering guidance, and delivering strategic support (Belland et al., 2013; Huang et al., 2020; Kordaki, 2011; Lim et al., 2011; So et al., 2019).

Scaffolding is widely used in teacher–student interactions to help students complete problem-solving tasks in game-based learning, with the overall aim of developing content understanding and skills. Meanwhile, the teacher plays an important role in the scaffolding process by providing adaptive and appropriate support to address students' struggles (Belland et al., 2013; Feng & Chen, 2014; Reiser, 2004). However, Barzilai and Blau (2014) stated that integrating teacher scaffolding into game-based learning might "negatively impact learners' perception of learning and enjoyment in the game" (p. 65). Therefore, it is crucial to gain an in-depth understanding of the effects of scaffolding on game-based learning to successfully apply the concept as a method for facilitating learning.

1.4. Purpose of the review

A number of previous review studies have focused on analyzing the impact of game-based learning in education. For example, Hainey et al. (2016) conducted an SLR of 105 studies published from 2000 to 2013 on game-based learning in primary education to conclude that there are various learning and behavioral outcomes and impacts of playing games, including behavioral change, affective and motivational outcomes, development of perceptual and cognitive skills, knowledge acquisition, and content understanding. Recently, Pan et al. (2022) conducted a systematic review of 43 studies to examine the use of games for mathematics learning in K–12 settings, where they discussed the various trends with regard to using games in mathematics education and appropriate ways for designing and integrating mathematics content into games. Furthermore, earlier review studies have also provided useful evidence for the integration of the teacher's role into game-based learning in education. For example, Kangas et al. (2017) conducted a qualitative literature review of 35 identified studies on game-based learning, published between 1998 and 2013, across various educational levels. The results of this study constructed a categorization of teachers' pedagogical activities, from planning to reflection, in the game-based learning process. Sun et al. (2021a) also conducted a review of 22 studies with the aim of investigating teachers' pedagogical activities in digital game-based learning in primary education. However, this review study primarily explored teachers' pedagogical activities only during the digital gameplay phase, with no information reported on the other phases. In addition, although the teacher plays an important role in game-based learning, some studies have shown that scaffolding in teacher–student interactions may not always be effective due to the implementation of inappropriate scaffolding approaches (Barzilai & Blau, 2014; Chen et al., 2013; Wang, 2020), such as noncontingent interaction (Hermkes et al., 2018) and too much "hands on" or "hands off" support (Hermkes et al., 2018; Kirschner et al., 2006; Reusser, 2001). Therefore, it is crucial to attain a deeper understanding of scaffolding in teacher–student interactions within game-based learning to successfully apply it in a way that facilitates learning. In other words, further research on how teachers scaffold the various game-based learning stages and the correlated influences on student learning would be immensely helpful for the advancement of studies on game-based learning.

This literature review combines the findings from papers published during the period January 2011 to the end of March 2022 to provide an overview of the current state of the scaffolding strategies used in teacher–student interactions within game-based learning in primary education, while also identifying the influence of teacher scaffolding on primary school students' learning. Specifically, the aim of this review is to address the following questions: (1) What games have been used in game-based learning research? (2) What kinds of scaffolding strategies are used by teachers in teacher–student interactions within game-based learning in primary education? (3) What empirical evidence exists regarding the influence of the scaffolding strategies used in game-based learning on primary students' education?

2. Methodology

To answer the above questions, an SLR was conducted. This research method, which can be used to summarize, appraise, and mediate evidence by providing synthesized reviews on significant issues, is appropriate for the purpose of this study (Borrego et al., 2014; Petticrew & Roberts, 2006). The SLR approach enables the advancement of current knowledge on research topics by promoting evidence-based activities (Cook, 1998; Egger & Smith, 2001; Horvath & Pewsner, 2004), conducting more objective assessments of past efforts, and identifying new directions for research (Borrego et al., 2014). Compared to a narrative literature review, the SLR uses a strict methodology in a documented and structured manner that results in more reliable and valid conclusions (Cook, 1998; Petticrew, 2001; Sawyer, 2017). As an efficient method for searching previous studies from data sets and large-scale literature, the SLR can be deployed to gather all relevant data on scaffolding strategies utilized in teacher–student interactions within game-based learning, as well as analyze their impact on primary students' learning (Cook, 1998; Petticrew, 2001). To ensure that our SLR was systematic, we followed the PRISMA guidelines (Page et al., 2021).

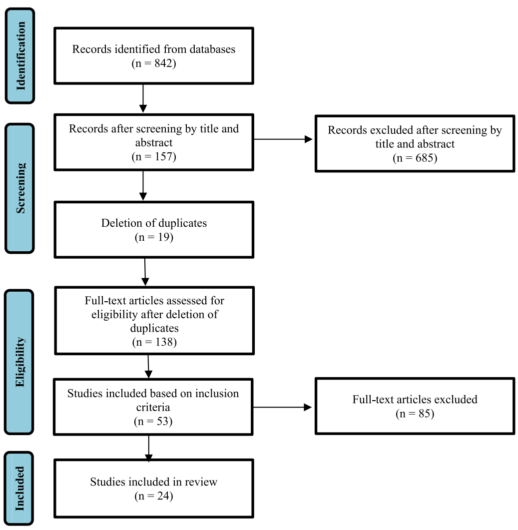

Fig. 1. Flowchart illustrating the review selection process.

2.1. Procedure

The electronic scientific databases that were searched to identify relevant studies included ScienceDirect (Elsevier), Web of Science, SpingerLink, EBSCO (Academic Search Elite, Eric-Education), Eric-Education Collection (ProQuest), and Scopus. The selection of these databases was based on their multidisciplinary scope, accessibility, and relevance to the theme. The search process was finalized by the end of April 2022.

The selected search terms were derived from searches that had been conducted in previous game-based learning research (Kangas et al., 2017; Hainey et al., 2016; Ke, 2016; Perttula et al., 2017): scaffolding ("digital game" OR "video game" OR "serious game" OR "mobile game" OR "educational game" OR "learning game" OR "game-based learning") ("primary education" OR "primary school students").

A literature search of the electronic scientific databases was conducted by deploying the PRISMA framework (Page et al., 2021). This procedure was split into four phases: (1) identification, (2) screening, (3) eligibility, and (4) inclusion, as shown in Fig. 1.

As shown in Fig. 1, the first phase involved conducting a systematic search of the electronic databases. Studies were selected if they met the following inclusion criteria: (a) the study conducted empirical research on game-based learning, (b) the participants in the study were students pursuing primary education, (c) the study was published between 2011 and the end of March 2022 (due to the rapid development of game-based learning in primary education, it was necessary to present and better understand the influence of teachers' scaffolding strategies on primary students' learning in game-based learning in the last 10 years), (d) the study was peer reviewed, and (e) the study was written in English. We excluded studies examining special populations and game-based learning in primary education (e.g., participants with gifted or special educational needs) and those whose findings were obtained from clinical samples.

This search process generated 842 results. Subsequently, the second phase involved screening the titles and abstracts of the shortlisted studies. In total, this screening procedure resulted in 157 relevant papers, of which 19 were found to be duplicates while synthetically examining the screening results. The third phase involved assessing the eligibility of 138 shortlisted full-text articles. This process included reading the papers in detail and selecting those that aligned with the following inclusion criteria: (a) the study included relevant information about teacher scaffolding, (b) the study included relevant information about games, and (c) the study included relevant information about its research methods. Following this process, the 53 papers that met the selection criteria were considered for the final extraction. In the final phase, the quality of the papers ($n = 53$) was assessed based on the research questions. Finally, 24 papers (Appendix A) that addressed both research questions were included and used for data coding and analysis.

2.2. Data coding and analysis

Content analysis was adopted and implemented as the methodology for coding the selected papers, as it is best suited for synthesizing findings from educational research studies (Borrego et al., 2014; Mayring, 2000; Seuring & Gold, 2012). The coding scheme included four stages.

First, we extracted information from the selected studies, evaluated them, and then created a coding table to document them (Kangas et al., 2017; Randolph, 2009). Subsequently, the information was divided and coded into two tables: one contained basic information about the student participants (number, age, and gender), teacher participants (number), the research design and methods, the school subject, and the game used in the experiment (cf. Kangas et al., 2017; Ke, 2009; Perttula et al., 2017), while the other contained scaffolding information, including the particular stage of game-based learning, scaffolding strategies implemented in teacher–student interactions, students' level of attainment in these interactions, and the influence of teacher scaffolding on students in game-based learning.

Second, to construct descriptive themes, we organized and labeled the codes according to their relevant areas of importance (Perttula et al., 2017). According to the categories identified by Kangas et al. (2017), we grouped the codes according to two stages of game-based learning: the orientation stage and the gameplay stage.

Third, to develop the themes, we grouped the studies with similar kinds of labels into the same categories. In the case of the game used in the experiments, we focused on the features of the game in the selected studies and identified game genres based on the categories identified by Ke (2016), game functions (e.g., knowledge presentation, drill and practice, and knowledge application), gameplay mode (e.g., individual or collaborative), gameplay period (e.g., the number of learning sessions for gameplay and the duration of gameplay), digital or nondigital format, digital games' scaffolding functions based on the identification process suggested by Fisch (2005), and role of the teacher based on Kangas et al.'s (2017) identification criteria. For the research methods used to examine game-based learning in primary education, we identified the research design of the studies (e.g., randomized control trial, experimental design, qualitative design) and classified them into two categories: experimental design and nonexperimental design. Furthermore, to analyze the scaffolding strategies used in teacher–student interactions in terms of the concerns raised in previous research (e.g., Sun et al., 2021b; Belland et al., 2013; Huang et al., 2020; Kordaki, 2011; Lim et al., 2011; So et al., 2019) and descriptions in earlier review studies, we classified the orientation stage into three categories (introduction, assistance, and review) and the gameplay stage into four categories (guidance, encouragement, feedback, and intervention). The students' level of attainment from teacher–student interactions was identified on the basis of Hermkes et al.'s (2018) classification, which ranges from "no understanding of the task" to "attaining the correct solution" (p. 149). To study the influence of teacher scaffolding on student learning, we summarized its benefits for the field of game-based learning as presented in previous research (e.g., Atmatzidou & Demetriadis, 2017; Kangas et al., 2017; Dukuzumuremyi & Siklander, 2018; Sun et al., 2021b; Chen & Law, 2016) and defined it based on the descriptions provided in previous review studies. By doing so, three categories in the orientation stage (familiarization with games, familiarization with learning activities, and reflection on prior knowledge) and five categories in the gameplay stage (knowledge acquisition, knowledge connection, engagement, skill development, and enjoyment) were identified.

Fourth, more detailed analytical themes were constructed. To answer the research questions, the labels and categories related to scaffolding strategies used in teacher–student interactions and students' level of attainment from them were organized in one table, while those related to the influence of teacher scaffolding on primary students' learning were organized in another. Additionally, Cramer's V was adopted to measure how strongly the influence of the scaffolding strategies used in game-based learning is associated with primary school students' learning. In addition, to ensure the coding quality of the papers, all were first coded and then recoded by the first two authors.

2.3. Quality of the studies

We assessed the quality of the selected papers using the five-dimension criteria created by Connolly et al. (2012): (1) appropriateness of the research design for addressing the research questions, (2) appropriateness of the methods and analysis, (3) generalizability of the findings, (4) correlation between the study's focus areas and research questions, and (5) credibility of the findings. All selected papers met the criteria based on these five dimensions.

3. Results

Altogether, 24 relevant papers were included in this systematic review. Together, these studies covered a total population of 2371 student participants. The number of teacher participants—a value reported in 21 of the selected studies—was 55, although three studies did not specify this data. Furthermore, only 12 papers (50%) reported the number of male and female participants separately. As expected, the age range generally extended from the first grade to the sixth grade (6–13 years old). Moreover, the learning settings described in all the reviewed papers were regular school classes. The research papers deal with different kinds of games that are used for educational purposes. Some games were found to have been used in multiple papers, which were mainly written by the same authors but on different topics. The studies included in this review were based in Greece (1), Estonia (1), the United States (3), Singapore (6), Belgium (1), Cyprus (2), Taiwan (5), Hong Kong (1), Canada (1), Finland (1), South Korea (1), and Australia (1). A summary of the participants, research design, subjects, and games used in each study is presented in Appendix B.

3.1. Research design

The use of both experimental and nonexperimental designs was identified in the reviewed studies, with 13 (54%) following an experimental design and 11 (46%) following a nonexperimental design. The experimental designs were further classified into three types: pre-experimental design (no comparison group and no random selection and assignment of subjects), true experimental design (presence of comparison group characterized by random selection and assignment of subjects), and quasi-experimental design (presence of comparison group but no random selection and assignment of subjects). The nonexperimental designs were classified into two types: qualitative design, which uses qualitative methods to collect data, and design-based research, which tries to solve current real-world problems by designing and enacting interventions, extending theories, and refining design principles (Barab & Squire, 2004; Wang & Hannafin, 2005). Among the 13 studies that used experimental designs, quasi-experimental designs (n = 6, 46%) were more prevalent than pre-experimental (n = 4, 31%) and true experimental (n = 3, 23%) designs. Meanwhile, among the 11 studies that used nonexperimental designs, qualitative designs (n = 8, 73%) were more popular than design-based research (n = 3, 27%). Notably, pretest and posttest group comparison was identified as the most popular technique (n = 10, 42%), and included comparisons of game and nongame conditions (n = 3), comparisons of the impact of knowledge improvement before and after gameplay (n = 6), and comparisons of the effect of independent and collaborative learning on gameplay (n = 1). The data collection methods deployed in each reviewed study are noted in Appendix B, and the sample size for each research design is recorded in Table 1.

The sample size in each research design was classified based on the criteria used in previous studies (e.g., Ghasemi & Zahediasl, 2012; Pan et al., 2022; VanVoorhis & Morgan, 2007), as small (<50), medium (50–200), and large (>200). As shown in Table 1, about 67% of all studies were conducted with medium to large sample sizes, ranging from 50 to 305 participants. Meanwhile, qualitative design studies were normally conducted with small samples, ranging from 10 to 28 participants.

Table 1
Sample size by research design.

Research design	Sample size		
	Small (<50)	Medium (50–200)	Large (>200)
Pre-experimental design		2	2
True experimental design		2	1
Quasi-experimental design	2	4	
Qualitative design	5	2	1
Design-based design	1	1	1
Total	8	11	5

3.2. Game variables

3.2.1. Subject disciplines

The games identified in the reviewed studies were directed at improving students' knowledge of different subject disciplines related to primary education. A summary of the subject disciplines addressed in the reviewed studies is presented in Table 2.

As shown in Table 2, the most popular subjects in terms of the application of game-based learning was science (n = 8), while the least popular subjects were writing (n = 1) and moral education (n = 1). Meanwhile, one of the shortlisted studies did not specify the subject.

3.2.2. Game genre

It should be noted that when the same game was developed and used in different studies or when a study used two games that employed the same learning theory, they were considered as one game in the review. As a result, 19 unique games were identified from the 24 selected articles. Among them, puzzle games (n = 7) were the most popular genre, closely followed by construction games (n = 5), simulation games (n = 2), role-playing games (n = 2), adventure games (n = 2), and strategy games (n = 1).

3.2.3. Game function

All the learning games identified in the reviewed studies were designed and used for teaching primary school students (n = 24). Among the selected studies, only one (n = 1) chose a learning game for the purpose of the presentation and construction of novel knowledge, while the remaining were designed for use as complementary tools to aid in instruction for developing knowledge and skills—for example, a tool for drilling and practicing previously learned knowledge (n = 9) and a tool for developing and applying learned knowledge and skills (n = 14).

3.2.4. Digital/nondigital

Since the focus of the current study was game-based learning, both digital and nondigital games were included in the search process. The results showed that digital games (n = 18) were the more popular and prevalent game type in primary education, while only one study (n = 1) used a nondigital game to support mathematics learning in primary education.

3.2.5. Game play mode and period

With regard to the type of play mode, the studies were divided into three categories: individual (n = 9), collaborative (n = 12), and mixed play modes (n = 3). The collaborative play mode was the primary choice among the reviewed studies, comprising 50% of the total number of studies, followed by individual (37%) and mixed play (13%) modes. Furthermore, the amount of time students spent playing the games varied greatly. The results showed that half of the studies (n = 12) examined the game-based learning process for more than one learning session, with the duration of investigation ranging from 135 to 840 min. On the other hand, a few studies (n = 6) investigated game-based learning in only one learning session, the duration of which ranged from 15 to 75 min. The remaining studies did not specify the period of gameplay (n = 6).

3.2.6. Scaffolding function in the game and the role of teachers

Among the 18 digital games, a few studies (n = 7) had scaffolding functions, whereas one study (n = 1) did not have scaffolding functions, and the others (n = 10) did not specify scaffolding functions in the game. Furthermore, with regard to the type of scaffolding function in the game, three major categories were identified in accordance with Fisch (2005): help (n = 1), feedback (n = 5), and hint instructions (n = 5). Feedback and hints were the main options when designing scaffolding in the game, and a few games (n = 3) applied more than one scaffolding function in the game design. In addition, with regard to the role of the teachers, the studies were divided into three major categories according to Kangas et al. (2017): facilitator (n = 13), guide (n = 3), and mixed roles (n = 8). The facilitator was the main role of the teachers among the reviewed studies, comprising 54% of the total studies, followed by mixed roles (33%) and guides (13%).

3.3. Scaffolding strategies used in teacher–student interactions

In response to the second research question, we identified the scaffolding strategies in teacher–student interactions that the

Table 2
Summary of the subject discipline addressed in the reviewed studies.

Subject discipline	Total
Computer science	2
Science	8
Language	6
Mathematics	5
Writing	1
Moral education	1
Not specified	1

teachers implemented in game-based learning settings. The results of this investigation are presented in the following subsections.

3.3.1. Scaffolding strategies in the orientation stage

Eleven studies provided scaffolding during the orientation stage of game-based learning. Table 3 notes the categories of the scaffolding strategies in teacher–student interactions implemented during the orientation stage that were identified in the reviewed studies.

It is evident from Table 3 that the most commonly used scaffolding strategy was introduction (nine studies). This is reasonable because students need to familiarize themselves with the game and clarify their learning goals before initiating gameplay. Generally, introductions are carried out for the whole class at the same time. For example, a recent study by Lin et al. (2022) noted that the teacher first introduced students to the gaming platform environment and their learning goals, which was the first step in introducing students to programming. In another case, Georgiou and Ioannou (2021) observed that the classroom teacher began the lesson with a 10-min presentation directed at introducing students to the topics of the lesson and the learning activities that followed. In addition, both assistance (one study) and review (two studies) were offered during the orientation stage of game-based learning. In Hooshyar et al.'s (2021) study, the teacher provided technical help and basic instructions about the AutoThinking game to make it easier for the experimental group to learn computational thinking content during the learning sessions. Meanwhile, Wong et al. (2013) found that a quick review of what had been covered in previous sessions before gameplay began in the current lesson was a common method used by teachers in the course of teaching new lessons on Chinese character structure.

3.3.2. Scaffolding strategies in the gameplay stage

Among the sample of reviews examined in the current study, 23 provided scaffolding during the gameplay stage of game-based learning. Table 4 notes the different categories of scaffolding strategies in teacher–student interactions implemented during the gameplay stage that were identified in the reviewed studies.

As shown in Table 4, the teachers implemented four main categories of scaffolding strategies during the gameplay stage of game-based learning—guidance, encouragement, feedback, and intervention.

Guidance. Nineteen studies fit into this category, with the most frequently used guiding strategies being teacher-directed prompts, modeling, explicit instruction, and teacher-led discussion. For example, when students used Scratch to design and develop computer games, teacher-directed prompts, such as asking questions, helped them integrate environmental content into the features of the games they created (Baytak & Land, 2011). In Kyriakides et al.'s (2016) study, the teacher prompted students to reconsider a rectangular image in their minds by asking challenging questions. Furthermore, Gan et al. (2021) found that teachers often modeled sophisticated knowledge using expressions that encouraged students to find ways in which they could advance and improve the ideas in their graphical notes. In Wilkerson et al.'s (2018) study, the classroom teacher provided explicit instructions on ways to construct animations that could be easily turned into simulations, which the students could then follow to complete tasks during the second modeling cycle in the siMSAM modeling environment. In addition, a teacher-led discussion conducted during the gameplay stage was identified. Bragg (2012) used teacher-led whole-class discussions to investigate whether students could learn more mathematical concepts by playing games independently without any discussion.

Encouragement. Eight studies whose general aim was to ensure that students focused on learning activities and persisted in completing tasks were identified in this category. For example, in Kordaki's (2011) study, students were encouraged to concentrate on the number of dots to search for numerical relationships among them. In another study, the students reported that the teacher encouraged them to explore further when they encountered difficulties while solving puzzles in Wuzzit Trouble (Sun et al., 2021b).

Feedback. Five studies in the sample were found to fit into this category, which represents one of the central components of scaffolding (Belland et al., 2013; van de Pol et al., 2010). The most frequently used feedback was just-in-time feedback. For instance, in Zou's (2020) study, the teacher assessed students' learning and provided them with instant and constructive feedback on their gameplay on the Edpuzzle and Kahoot! platforms while they were still in the classroom. This finding is consistent with Wong et al. (2013), who reported that the teacher used a projected teacher console to give students immediate feedback on the characters they formed.

Intervention. Eight studies were identified in this category, with the most frequently used intervention strategies including triggering interaction, time management, and classroom organization. For example, in Wen's 2018 and 2021 studies, the teacher asked the students to engage in collaborative dialogue so that they could present and elucidate their group artifacts by cooperating with each other. This finding is consistent with that of Liu et al. (2021), who reported that the teacher motivated students to discuss with group members when they encountered problems while working on a computer. Furthermore, when the Chinese-PP game was used in the classroom, the teacher conducted time management activities by controlling the game's pace and determining when to end a round (Wong et al., 2011, 2017). Additionally, in Sun et al.'s (2021b) study, classroom organization, such as locking tablet screens and

Table 3
Scaffolding strategies used in the orientation stage in the reviewed studies.

Scaffolding strategies	Study numbers (Appendix A)										
	1	2	5	7	9	10	11	15	17	21	22
Introduction	x		x	x	x	x		x	x	x	x
Assistance		x									
Review	x						x				

Table 4
Scaffolding strategies used in the gameplay stage in the reviewed studies.

Scaffolding strategies	Study numbers (Appendix A)																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Guidance	x		x			x		x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
Encouragement	x		x					x	x					x			x							x
Feedback			x		x					x	x				x									
Intervention				x	x		x				x	x	x				x				x			

clapping hands, helped students concentrate on teacher-directed prompts and teacher-led discussions.

3.3.3. Students' level of attainment in teacher–student interaction

This section presents the development of students' level of attainment (Hermkes et al., 2018) based on the different scaffolding strategies used in teacher–student interactions within game-based learning. An overview of the students' level of attainment is presented in Table 5.

As shown in Table 5, nine studies identified that introduction, as one of the scaffolding strategies used in the orientation stage, could support the development of the students' level of attainment (SLA) from SLA 1 to SLA 3. The reason for this is probably that the aim of the orientation stage in game-based learning is to provide students with sufficient knowledge about the game. In this stage, teacher–student interactions were primarily built upon students asking for help in understanding the game and the teacher scaffolding through conversation. For example, in Kordaki's (2011) study, after the teacher introduced the game and the rules of gameplay, every student clicked on the new card and immediately asked for help understanding the binary numbers shown on the card. Later, by answering the teacher's questions, the students understood the binary numbers, which were illustrated on their cards, and managed to play the game independently (Kordaki, 2011).

After familiarizing themselves with the game, the students needed to solve its learning tasks. In the gameplay stage, two scaffolding strategies—guidance (n = 18) and feedback (n = 5)—were observed to provide support to students in developing their level of attainment from SLA 4 to SLA 5. In this stage, teacher–student interactions were built upon the teacher's diagnostic dialogues. Asking relevant questions during gameplay was one of the common approaches used by teachers to diagnose students' current understanding and then to choose the appropriate guiding strategy accordingly. For example, in Sun et al.'s study (2021b), the mathematics teacher diagnosed the main obstacle to the students' problem-solving abilities by asking them questions and then guiding them to analyze the problem, providing hints when necessary so that the students became aware of their mistakes and solved the puzzles correctly. This interactive process improved the SLA from SLA 4 to SLA 5. Furthermore, observing the students' gameplay also enabled the teacher to collect diagnostic information about their current level of understanding, which helped the teachers provide tailored support, such as feedback. For example, in Wong et al.'s study (2013), the Chinese teacher first observed the characters formed by the students on her laptop and then presented the correct and incorrect characters on the shared display in the middle of the gameplay, providing just-in-time feedback to the students, which helped them become aware of their incorrect composition and note the correct solution. Effectively, this interactive process helped students reach the SLA 5 level.

3.4. Influence of teacher scaffolding on students' learning

This section addresses the third research question. Tables 6 and 7 present a detailed overview of how strongly the influence of the scaffolding strategies used in game-based learning is associated with primary students' learning.

Table 6 shows the three categories of the influence of teacher scaffolding on students' learning in the orientation stage. According to the results shown in Table 6, Cramer's V is 0.720, which indicates a strong association between scaffolding strategies in the orientation stage and student learning in game-based learning. For example, introduction, one of the most prominent scaffolding strategies in the orientation stage, exhibited a particularly strong influence on students' familiarization with games (n = 7) in the reviewed studies.

Table 7 shows the five categories of the influence of teacher scaffolding on students' learning in the gameplay stage. According to the results shown in Table 7, Cramer's V is 0.364, which indicates a moderate association between scaffolding strategies in the gameplay stage and students' learning in game-based learning. For example, the results indicated that guidance, one of the scaffolding strategies used in the gameplay stage, had a particularly strong influence on students' knowledge acquisition (n = 7) and engagement (n = 7), but it had a weak influence on students' knowledge connection (n = 1) in game-based learning. The influence of each category during the orientation and gameplay stages on students' learning in the reviewed studies is detailed below.

3.4.1. Influence of teacher scaffolding in the orientation stage

This study identified three kinds of influence of teacher scaffolding on students' learning in the orientation stage of game-based learning—familiarization with the game, familiarization with the learning activity, and reflection on prior knowledge. In the reviewed studies, teacher scaffolding was frequently provided during the orientation stage to all students to help them familiarize

Table 5
Students' level of attainment through teacher–student interactions in the reviewed studies.

Students' level of attainment (SLA)	Orientation stage	Gameplay stage	
	Introduction (n = 9)	Guidance (n = 18)	Feedback (n = 5)
1. No understanding of the task	x		
2. Misunderstanding the task	x		
3. Correct understanding of the task, but no solution generated for the time being	x		
4. Generating an inappropriate/false solution without noticing the mistake		x	x
5. Generating an inappropriate/false solution and realizing that it is inappropriate/false		x	x
6. Obtaining the appropriate/correct solution and judging it as valid			

Note. x indicates the level of attainment achieved by students based on the different scaffolding strategies used in teacher–student interactions.

Table 6
Research on the effects of teacher scaffolding on student learning in the orientation stage.

Scaffolding strategy	Influence on student learning			Total	Cramer's V
	Familiarization with games	Familiarization with learning activities	Reflection on prior knowledge		
Introduction	7	3		10	0.720
Assistance	1			1	
Review			2	2	
Total	8	3	2	13	

Note. The numbers represent the total number of studies that identified the influence of teacher scaffolding strategies on student learning.

Table 7
Research on the effects of teacher scaffolding on student learning in the gameplay stage.

Scaffolding strategy	Influence on student learning					Total	Cramer's V
	Knowledge acquisition	Knowledge connection	Engagement	Skills development	Enjoyment		
Guidance	7	1	7	5	2	22	0.364
Encouragement			4	2	2	8	
Feedback	2	2	3			7	
Intervention			4	2		6	
Total	9	3	18	9	4	43	

Note. The numbers represent the total number of studies that identified the influence of teacher scaffolding strategies on student learning.

themselves with the game, the gaming process, and the learning activity. Students need to possess proper knowledge of the gameplay process and the expected results when learning through games (Belland et al., 2013). For example, Sun et al. (2021b) found that the teacher's whole-class scaffolding, which was conducted in the orientation stage, easily familiarized the students with Wuzzit Trouble, who preferred practicing and solving integer-arithmetic problems by playing the digital game. Moreover, in Lin et al.'s (2022) study, the teacher's introduction, using the example of Dako Island in E-game, made students familiar with the basic operations and functions of the game, as well as the goals of learning related to it. In another study, Liu et al. (2021) claimed that an introduction describing the activity's theme and hardware structure could help students practice and experience programming effectively with mBlock. In addition, scaffolding provided during the orientation stage also made students review and reflect on their prior knowledge. For example, Kordaki (2011) stated that the teacher's directed prompts helped students review the formation of any decimal number with 10 digits, analyze the decimal numbers presented on their cards, and assess the values of the digits and their interrelationships.

3.4.2. Influence of teacher scaffolding in the gameplay stage

In the reviewed studies, five significant influences of teacher scaffolding on students' learning in the gameplay stage of game-based learning were identified—knowledge acquisition, knowledge connection, engagement, skills development, and enjoyment. Among these influences, engagement was observed to be the most relevant, while enjoyment was the least significant.

Knowledge Acquisition. Seven studies were observed to fit into this category, with the acquisition of subject knowledge being the most significant factor. For example, Zou (2020) found that because the teacher separately explained each assessment item in Kahoot!, the students could further consolidate their basic knowledge of English. In another study, Cheng and Tsai (2020) observed that the teacher's guidance was able to imbue students with a high level of self-regulation in attaining scientific knowledge and, in turn, supported their science learning. However, other studies have emphasized that the scaffolding provided by teachers in the gameplay stage results in a negative influence on students' knowledge acquisition (Boticki et al., 2015; Bragg, 2012). In Bragg's (2012) study, students who played the games along with a discussion group exhibited relatively less improvement than those who played without a discussion group. This finding is consistent with that of Boticki et al. (2015), who noted that participants in the self-directed group achieved better scores in their final assessment than those in the teacher-directed group.

Knowledge Connection. Two studies from the sample fit into this category, both of which primarily examined the connection between knowledge and games. In Baytak and Land's (2011) study, the teacher's guiding discussion helped students combine environmental content with the game's features, which enabled them to think about new game features and have their ideas reflected in the games they created. In another study, Kyriakides et al. (2016) claimed that the teacher's adaptive instructions and feedback during gameplay helped students overcome obstacles related to the most common rectangular images.

Engagement. Thirteen studies were identified as belonging to this category. Among them, 11 considered the scaffolding provided by the teacher during the gameplay stage to have a positive influence on students' learning. For example, in Wilkerson et al.'s (2018) study, the teacher's directed prompts helped students who had trouble creating a model to produce a working simulation, thus preparing them to engage in more complex modeling and reasoning activities. In another study, Wong et al. (2011) found that due to the teacher's intervention, students who were still looking for groups could join a new group of classmates to explore possible solutions to forming an accurate Chinese character. In addition, Gan et al. (2021) stated that the teacher's encouragement contributed to improving students' idea-centered drawing and writing performance in the Knowledge Forum. In contrast to these findings, two studies claim that scaffolding provided by teachers has a negative influence on student engagement (Chuang et al., 2021; Wong et al., 2017). For example, in Wong et al.'s (2017) study, the results indicated that the teacher's preoccupation with providing direct instructions gave students little time to play the game, which caused them to rush through it or limit the number of rounds they played.

Skills Development. Nine studies, the majority of which focused on problem-solving, collaborative, and social skills, were identified as belonging to this category. Among these, four studies found that teacher scaffolding during the gameplay stage had significant effects on students' problem-solving skills. Three studies observed that students were able to solve difficult problems while working on the exercises under the teacher's guidance (Kyriakides et al., 2016; Lin et al., 2022; Neutens et al., 2021), whereas one study concluded that, compared to field-independent students, field-dependent students relied more on external guidance from the teacher or peers on encountering difficulties (Chuang et al., 2021). Moreover, three studies found that teacher scaffolding had a considerable impact on students' collaborative skills. Two of these studies claimed that the teacher's intervention made students more willing to help and learn with each other, thus achieving effective collaborative interaction during gameplay (Baytak & Land, 2011; Wong et al., 2013). However, in Wong et al.'s (2017) study, the teacher's direct instructions were observed to prevent the development of collaboration among students during the first research cycle of playing the Chinese-PP game. In addition, three studies found that the teacher's guidance had a substantial impact on students' social skills. Under the teacher's guided discussion, students were encouraged to converse with their peers, share strategies and ideas, and learn from each other (Baytak & Land, 2011; Ilten-Gee & Hilliard, 2021; Wong et al., 2013). Moreover, the social climate in the classroom afforded opportunities for students to upskill through peer teaching (Baytak & Land, 2011).

Enjoyment. Two studies were found to fit this category. The results of Sun et al.'s (2021b) study indicated that the teacher's guidance during the gameplay stage stimulated students' interest in mathematics to a greater extent than it had been previously, while also increasing their willingness to learn mathematics. In another study, Kordaki (2011) found that due to the teacher's guidance and encouragement, students were more interested in participating in game-based experiences—they expressed that they had fun and were motivated to be involved in the gameplay.

4. Discussion and conclusion

The current paper presents an SLR of research conducted on teacher scaffolding within game-based learning in primary education between 2011 and the end of March 2022. A four-phase PRISMA framework (Page et al., 2021) was applied to select the appropriate papers for the systematic analysis. The 24 selected papers that met the inclusion criteria were then coded. Based on the results of the abovementioned systematic analysis, the prominent aspects that emerged from the investigation of these studies are discussed below.

4.1. Teacher scaffolding strategies within game-based learning in primary education

Various scaffolding strategies were employed by the teachers in teacher–student interactions during both the orientation and gameplay stages of the reviewed studies. These findings support the argument that the teacher plays an important role in the different stages of game-based learning (Kangas et al., 2017, Dukuzumuremyi & Siklander, 2018; Hmelo-Silver & Barrows, 2006; Laine et al., 2016; Muhonen et al., 2016; Watson et al., 2011). Furthermore, this emphasizes that the teacher's role is not only that of a facilitator but also a guide, whose major task is to provide tailored and appropriate support when students encounter difficulties, be they cognitive, motivational, or communicative (Kangas et al., 2017; Hermkes et al., 2018). Even when the games themselves are designed well, the teacher's active role is significant when integrating them into learning (Atmatzidou & Demetriadis, 2017; Kangas et al., 2017; Barzilai & Blau, 2014; Chen & Law, 2016; So et al., 2019; Wen, 2018). Moreover, in scaffolding game-based learning environments, the students themselves act as "autonomous agents" who solve problems in the games, seek their own solutions, and then validate them (Hermkes et al., 2018, p. 153).

Eleven of the reviewed studies provided scaffolding in the orientation stage, with introduction being the most frequently used scaffolding strategy ($n = 9$). It is necessary for students to know and understand precisely what they will engage in as well as the expected results from the engagement when they learn through games (Belland et al., 2013). This can be ensured by providing an introduction before students begin gameplay. Similar results were reported by Kangas et al. (2017), who—in the review of 35 empirical studies published in the years 1998-2013 on teachers' pedagogical activities in game-based learning—found that the teachers started the gaming section by introducing the game, the gaming process, and its learning objectives. In addition, we found that assistance ($n = 1$) and review ($n = 2$) were also provided to the whole class, thus supporting students in familiarizing themselves with the game before they began gameplay.

It is significant to note that the results of the current review differed from previous studies (e.g., Kangas et al., 2017; Sun et al., 2021a) with regard to teacher scaffolding provided in the orientation stage, since prior research lacked any connection to the students' prior knowledge. In two of the reviewed studies, we observed that the teachers conducted a review of the students before beginning student gameplay. This finding suggests that a large number of researchers have emphasized the importance of reflecting on primary school students' prior learned knowledge even before starting the orientation stage instead of considering it only in the gameplay stage (Kordaki, 2011).

Twenty-three of the reviewed studies provided teacher scaffolding in the gameplay stage of game-based learning, with guidance being the most frequently used scaffolding strategy ($n = 19$), followed by intervention ($n = 8$), encouragement ($n = 7$), and feedback ($n = 5$). Our findings are consistent with those of van de Pol et al. (2010) and Belland et al. (2013), who indicated that scaffolding is a dynamic intervention in which the support provided by the teacher is contingent and should depend on the situation and the students' responses at the time. Notably, according to the scaffolding strategies categorized by Schmitt and Weinberger (2019), guidance and feedback may be identified as strategy scaffolding, which helps students think better and properly conduct their learning activities, thereby enabling them to proceed smoothly in the task solution procedure (Schukajlow et al., 2015; Sharples et al., 2015), while encouragement and intervention may be identified as verbalization scaffolding, which can facilitate students' elaboration of learning tasks by triggering them to build and share arguments (King, 1990; Schmitt & Weinberger, 2019).

4.2. Influence of teacher scaffolding on game-based learning in primary education

This literature review provides evidence of the influence of teacher scaffolding in the orientation and gameplay stages on students' learning within game-based learning in primary education. The findings show how strongly the influence of the scaffolding strategies used in the orientation and gameplay stages in game-based learning is associated with primary school students' learning. Furthermore, the findings support the argument that scaffolding strategies in teacher–student interactions are essential in helping students face challenges and making game-based learning more structured (Atmatzidou & Demetriadis, 2017; Dukuzumuremyi & Siklander, 2018; Chen & Law, 2016; So et al., 2019). In addition, it is emphasized that due to their age (ranging from 6 to 13 years old), primary school students may benefit more from dynamically generated teacher scaffolding strategies appropriate for game-based learning (Dukuzumuremyi & Siklander, 2018, Sun et al., 2021a, Sun et al., 2021b; Haataja et al., 2019).

This review further noted that familiarization with games was the most crucial effect of teacher scaffolding in the orientation stage, followed by familiarization with the learning activity and reflection on prior knowledge. It is worth mentioning that familiarity with the game increased primary school students' interest in the game as well as in the learning activities, meaning that it had a positive effect on their gameplay activities and expected learning outcomes (Sun et al., 2021b; Kordaki, 2011). Notably, many researchers have highlighted the importance of integrating teacher scaffolding into the orientation stage rather than only the gameplay stage (Sun et al., 2021b).

Furthermore, we found that engagement ($n = 13$) was the most significant influence of teacher scaffolding on students' learning at the gameplay stage, followed by skills development, knowledge acquisition, knowledge connection, and enjoyment. These findings are consistent with prior reviews (van de Pol et al., 2010), which highlight that the three key characteristics of scaffolding—contingency, fading, and the transfer of responsibility—are closely intertwined and have significant effects on students' gaming and learning experiences (Barzilai & Blau, 2014; Chen & Law, 2016; van de Pol et al., 2010). The current review found that teachers provided guidance, feedback, and intervention that were contingent on the level of understanding of both the whole class and the individual students, as well as encouragement that was contingent on the current performance of the individual students. When the teachers were certain that the students could engage well and solve the problems within the game either independently or collaboratively, they gradually withdrew their support (Sun et al., 2021b; Chen & Law, 2016). In the end, when the students were able to proceed to a higher level in the gameplay stage, no scaffolding strategies were needed or provided.

However, our findings also indicate that in some studies, the scaffolding provided by the teachers in the gameplay stage had negative influences. Some researchers (e.g., Boticki et al., 2015; Bragg, 2012) have noticed that teacher-led discussion might have passive effects on students' knowledge acquisition because the students might end up spending more time engaging in the discussion than learning through the game. Furthermore, some studies have revealed that the teacher's explicit instructions had a negative effect on student engagement and skills development because students had limited time to explore the game independently or collaboratively (Chuang et al., 2021; Wong et al., 2017). These findings may be interpreted as the teacher breaking away from the three key characteristics of scaffolding as well as the purpose of game-based learning. When the teacher provided excess scaffolding in the gameplay stage instead of gradually withdrawing support, the students were not sufficiently motivated to think about and engage in the game-based learning experience, which prevented the transfer of the responsibility of performing a task to the students (Barzilai & Blau, 2014; van de Pol et al., 2010; Wong et al., 2017).

5. Implications, limitations, and directions for future research

As with all research, the current study has certain limitations. First, since the search terms and databases considered in this review were limited, some relevant studies might have been missed. Second, this review provides an overview of the research conducted within a selected timeline, ranging from 2011 to the end of March 2022. As a result, empirical studies conducted before 2011 were excluded. Third, it should be noted that some of the selected studies provided limited descriptions of the scaffolding strategies provided by the teacher, particularly with regard to the gameplay stage of game-based learning.

The review findings detailed above provide initial insights into the categories and influences of teacher scaffolding within game-based learning in primary education. It should be noted that this review specifically deals with studies conducted between 2011 and 2022 (end of March). Consistent with prior review studies (e.g., Kangas et al., 2017; Sun et al., 2021a), the current study supports the feasibility of employing teacher scaffolding in the orientation and gameplay stages of game-based learning. However, more research is warranted to ensure accurate recommendations regarding the use of different scaffolding strategies for teaching primary students in game-based learning settings. Considering this context, the present review has a set of implications for teachers, teacher educators, and game developers. First, teachers can benefit from the results of this review in designing game-based learning processes. Teachers may find this review useful for the purpose of suggesting new ways to provide primary school students with adaptive support during the different stages of game-based learning based on student responses. In other words, appropriate scaffolding strategies in teacher–-student interactions need to be considered in the pedagogical design so that the effects of teacher scaffolding on primary school students' learning in game-based learning environments function better. Meanwhile, teachers should balance scaffolding and students' individual learning so that students do not feel overwhelmed by the teacher's support or develop too much reliance on the teacher. The scaffolding process should lead students to take responsibility for their learning and deepen their understanding of subject knowledge while addressing any hindrance to their ability to comprehend learning tasks and problem-solving methods (Feng & Chen, 2014; Kim et al., 2015). Second, this review can help teacher educators to identify new ideas for developing game-based learning pedagogy in teacher education. Moreover, teacher educators need to provide opportunities for preservice and in-service teachers to design and develop various kinds of scaffolding strategies with the aim of integrating them into game-based learning environments. Third, game developers can use new knowledge derived from this review to design games that dynamically generate scaffolding functions that address students' struggles during the gaming process. Well-designed scaffolding functions within a game will enable primary school students to apply their knowledge and skills even in unfamiliar situations (Feng & Chen, 2014; Reiser, 2004).

Furthermore, this review identified several opportunities for future research on the investigation of teacher scaffolding in game-based learning. First, researchers should provide detailed descriptions of the scaffolding strategies used by teachers in the different stages of game-based learning. Second, more longitudinal and systematic research on teacher scaffolding in game-based learning needs to be conducted. For example, researchers have begun to highlight the effects of implementing teacher scaffolding at the orientation stage. In this context, further research should be conducted to investigate and provide crucial information on the effectiveness of teacher scaffolding throughout the entire procedure of game-based learning. Finally, further research is recommended on the possible contribution of teacher competencies to scaffolding students in game-based learning. Furthermore, researchers should adopt appropriate research designs when evaluating the teacher competencies required in game-based learning.

Statements and declarations

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CRediT authorship contribution statement

Liping Sun: Idea construction, data collection, data analysis, writing—original draft preparation and editing.
Marjaana Kangas: Idea construction, idea development, writing—reviewing and editing.
Heli Ruokamo: Idea development, writing—reviewing and editing.
Signe Siklander: Idea development, writing—reviewing and editing.

Declaration of competing interest

None.

Data availability

I have shared my data at the Attached file.

Acknowledgement

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Appendix A. List of the Papers Used in this Review

Study no.	Author details	Year	Title	Journal title
1	Kordaki	2011	A computer card game for the learning of basic aspects of the binary system in primary education: Design and pilot evaluation	*Education and Information Technologies*
2	Hooshyar, Malva, Yang, Pedaste, Wang, and Lim	2021	An adaptive educational computer game: Effects on students' knowledge and learning attitude in computational thinking	*Computers in Human Behavior*
3	Baytak and Land	2011	An investigation of the artifacts and process of constructing computers games about environmental science in a fifth grade classroom	*Education Technology Research and Development*
4	Wen	2021	Augmented reality enhanced cognitive engagement: Designing classroom-based collaborative learning activities for young language learners	*Education Technology Research and Development*
5	Wen	2018	Chinese character composition game with the augment paper	*Educational Technology & Society*
6	Neutens, Barbion, Coolsaet, and Wyffels	2021	Comparing learning ecologies of primary graphical programming: Create or fix?	*Journal of Computer Assisted Learning*
7	Georgiou and Ioannou	2021	Developing, enacting, and evaluating a learning experience design for technology-enhanced embodied learning in math classrooms	*TechTrends*
8	Wilkerson, Shareff, Laina, and Gravel	2018	Epistemic gameplay and discovery in computational model-based inquiry activities	*Instructional science*
9	Lin, Yang, Lin, Looi, and Chen	2022	Explorations of two approaches to learning CT in a game environment for elementary school students	*Journal of Computers in Education*

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(*continued*)

Study no.	Author details	Year	Title	Journal title
10	Zou	2020	Gamified flipped EFL classroom for primary education: Student and teacher perceptions	*Journal of Computers in Education*
11	Wong, Hsu, Sun, and Boticki	2013	How flexible grouping affects the collaborative patterns in a mobile-assisted Chinese character learning game?	*Educational Technology & Society*
12	Wong, Looi, and Boticki	2017	Improving the design of a mCSCL Chinese character forming game with a distributed scaffolding design framework	*Research and Practice in Technology Enhanced Learning*
13	Wong, Boticki, Sun, and Looi	2011	Improving the scaffolds of a mobile-assisted Chinese character forming game via a design-based research cycle	*Computers in Human Behavior*
14	Gan, Hong, Chen, and Scardamalia	2021	Knowledge building: Idea-centered drawing and writing to advance community knowledge	*Education Technology Research and Development*
15	Kyriakides, Meletiou-Mavrotheris, and Prodromou	2016	Mobile technologies in the service of students' learning of mathematics: The example of game application A.L.E.X. in the context of a primary school in Cyprus	*Mathematics Education Research Journal*
16	Ilten-Gee and Hilliard	2021	Moral reasoning in peer conversations during game-based learning: An exploratory study	*Journal of Moral Education*
17	Sun, Ruokamo, Siklander, Li, and Devlin	2021b	Primary school students' perceptions of scaffolding in digital game-based learning in mathematics	*Learning, Culture and Social Interaction*
18	Laine, Nygren, Dirin, and Suk	2016	Science Spots AR: A platform for science learning games with augmented reality	*Education Technology Research and Development*
19	Cheng and Tsai	2020	Students' motivational beliefs and strategies, perceived immersion and attitudes towards science learning with immersive virtual reality: A partial least squares analysis	*British Journal of Educational Technology*
20	Bragg	2012	Testing the effectiveness of mathematical games as a pedagogical tool for children's' learning	*International Journal of Science and Mathematics Education*
21	Liu, Huang, and Sung	2021	The determinants of impact of personal traits on computational thinking with programming instruction	*Interactive Learning Environments*
22	Tsai, Lin, and Liu	2020	The effects of pedagogical GAME model on students' PISA scientific competencies	*Journal of Computer Assisted Learning*
23	Chuang, Yeh, and Lin	2021	The impact of game playing on students' reasoning ability, varying according to their cognitive style	*Educational Technology & Society*
24	Boticki, Baksa, Seow, and Looi	2015	Usage of a mobile social learning platform with virtual badges in a primary school	*Computers & Education*

Appendix B. Summary of the Participants, Research Design, Subject, and Games used in Each Study

Study no.	Student participants	Teacher participants	Research design/Method	Game	Subject
1	N = 20 (f: 10, m: 10) Age: 6th graders	N = 1	- Pre- and posttest questionnaires were used to assess students' knowledge of binary numbers - Observations, field notes, video recordings, and screen shots were used to address students' involvement in card game play	*A computer card game* (unnamed) was designed to support primary school students in learning the basic aspects of the binary system	Computer Science
2	N = 79 (f: 36, m: 43) Age: 11–12 years	N = 1	- The experimental group used game as the learning approach, while the control group used a traditional technology-enhanced learning approach - Pre- and posttests were used to examine students' CT knowledge - A questionnaire on learning attitude adapted from Hwang and Chang (2011) was used for both the pre- and posttest questionnaires	*AutoThinking* was an adaptive educational game designed for increasing students' skills and conceptual knowledge in computational thinking	Science
3	N = 10 (f: 6, m: 4) Age: 5th graders	N = 3	- Mixed methods were employed in this study. Data sources included students' achieved games, semi-structured pre- and post-interviews, observations, field notes, video recordings, and journal entries	*Scratch* was an open-source programming environment that could be used by students to create computer games	Science
4	N = 53	N = 2	- Mixed methods were conducted in this study. Data sources included video recordings, focus group discussions, and teachers' semi-structured post interview	*Augmented Reality Enhanced Creating and Sharing (ARC&S) game* was an AR-enabled Chinese character learning game for lower primary school students in Singapore	Language (Chinese)

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Study no.	Student participants	Teacher participants	Research design/Method	Game	Subject
	Age: 8–9 years		- The experimental class played the ARC&S game, while the control class completed similar activities without using the ARC&S game		
5	N = 49 Age: 7–8 years	N = 1	- A quasi-experimental design was conducted in this study. Data sources included pre- and posttest, field notes, video recordings, focus group discussion, and the teacher's post-interview - The experimental class used the ARC game system, while the control class did not	*Augmented Reality-based Chinese Characters (ARC)* was designed for Chinese as second-language (L2) learners to develop Chinese orthographic knowledge and improve collaborative skills	Language (Chinese)
6	N = 211 (f: 53%, m: 46%, preferred to not identify: 1%) Age: 10–12 years	N = Not specified	- This mixed methods study involved both quantitative and qualitative assessments - Data sources for the quantitative assessment included a programming test, a computational thinking test, an attitude survey, and logging data - Data sources for the qualitative assessment included video recordings - The students were divided into two test groups—the create group and the fix group	*Scratch* was an open-source programming environment that could be used by students to create computer games	Science
7	N = 213 (f: 113, m: 100) Age: 3rd–5th graders	N = 8	- This study used a mixed methods research design. Data sources included students' testimonials on the learning experience design, pre–post conceptual test, engagement survey, and post-activity teachers' interviews	*Angle-makers* was designed to track students' arm movement using Kinect camera and create visual representation of their body movements on a screen	Mathematics (geometry)
8	N = 28 Age: 9–11 years	N = 1	-This study implemented the qualitative design research method. Data sources included video recordings, screen captures, and digital and physical artifacts	*Simulation, Measurement, and Stop-Action Moviemaking (siMSAM)* was a web-based application in which students could create stop-motion animation by using an external camera to capture photos of drawings or craft materials	Science
9	N = 51 Age: 5th graders	N = 2	- A quasi-experimental design was used in this study. Data sources included pre- and posttests, programming learning attitude questionnaire, classroom observations, video recordings, and semi-structured interviews. - The students were divided into two experimental groups—a collaborative learning group and an individual learning group	*E-game* was an online interactive teaching platform aiming to train elementary school students' computational thinking skills through games	Science (computational thinking)
10	N = 277 Age: 9–11 years	N = 8	- This study had a qualitative design. Data sources included in-class observations, interviews, meeting minutes, observation logs, and teachers' and students' self-reflections	*Edpuzzle* was a platform that organized and offered video and associated exercises, while providing students with immediate feedback *Kahoot!* was a free game-based learning platform providing students with immediate feedback	Language (English)
11	N = 15 Age: 10 years	N = 1	- This study used qualitative design research. Data sources included video and audio recordings, field notes, software logs, screen captures of the teacher console, and focus group interview	*Chinese-PP* was a mobile synchronous collaborative learning games that involved constructing Chinese characters from components and targeted students learning Chinese as a second language	Language (Chinese)
12	N = 84 Age: 3rd–5th graders	N = 1	- This study implemented design-based research. - The data sources in the first cycle included video and audio recordings, software logs, and focus group interview - The data sources in the second cycle included video and audio recordings, pre- and post-one-on-one semi-structured interviews with selected students,	*Chinese-PP* was a mobile synchronous collaborative learning game that involved constructing Chinese characters from components and targeted students learning Chinese as a second language	Language (Chinese)

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Study no.	Student participants	Teacher participants	Research design/Method	Game	Subject
			system logging, and paper-based pre- and posttests		
13	N = 37 Age: 10 years	N = 1	- This study implemented design-based research. - The data sources in the first implementation included video and audio recordings, software logs, and focus group interview - Students were divided into two subgroups. Subgroup A played a card game followed by a phone game, while Subgroup B played both games in reverse order	*Chinese-PP* was a mobile synchronous collaborative learning game that involved constructing Chinese characters from components and targeted students learning Chinese as a second language	Language (Chinese)
14	N = 22 (f: 11, m: 11) Age: 4th graders	N = 1	- This study used a mixed methods research design. Data sources included 332 notes across eight various Views in the Knowledge Forum database produced by students - The students were divided into two groups—high-drawing and low-drawing—based on the average number of drawings produced by each student	*Knowledge Forum* was a multimedia environment designed to support knowledge building through the use of various representational forms to record and improve ideas	Writing
15	N = 15 (f: 7, m: 8) Age: 10–11 years	N = 1	- This study used the qualitative design research method. Data sources included a background questionnaire and field notes	*A.L.E.X.* was an educational programming puzzle game available on iPad and Android tablet devices	Mathematics
16	N = 51 (f: 18, m: 23) Age: 10–12 years	N = 3	- This study used a mixed methods research design. Data sources included pre- and posttest and video recordings	*Quandary* was an online comic-book-esque game aiming to facilitate students' ethical decision making	Moral education
17	N = 141 (f: 64, m: 77) Age: 9–11 years	N = 4	- This study used the qualitative design research method. Data sources included classroom observations, field notes, and thematic interviews	*Wuzzit Trouble* was a tablet-based mathematics game available on the iTunes App Store and Google Play	Mathematics
18	N = 61 (f: 48%, m: 52%) Age: 12 years	N = 2	- This study used a mixed methods research design. Data sources included questionnaires and interviews	*Leometry* was a proof-of-concept game designed to teach basic geometric shapes to 5th and 6th graders	Mathematics (Geometry)
19	N = 76 (f: 37, m: 39) Age: 10–11 years	N = 3	- The Chinese version of Motivated Strategies for Learning Questionnaire (Lee, Zhang, & Yin, 2010) was used to understand students' motivated strategies in immersive virtual reality (IVR) learning - The Immersive Experience Questionnaire (IEQ) (Jennett et al., 2008) was used to examine students' perceived immersion in the IVR learning environment - The attitude survey used in Cheng's study (2017) on AR book reading was adopted to examine students' attitudes toward VR learning activities	*Expedition* was an application published by Google that enabled virtual field trips	Science
20	N = 112 Age: 10–12 years	N = 8	- A quasi-experimental design was used in this study. Data sources included three written achievement tests (pretest, posttest, and 10-week delayed posttest) - Students were divided into three groups. The first two groups included students conducting gameplay with and without formal teacher-led discussion sessions. The third group undertook nongame learning activities	*Guestimate* was a calculator game based on the multiplication of whole and decimal numbers *Hone on the Range* followed the same procedure as *Guestimate*, but the player aimed for a target within the range between two given numbers	Mathematics
21	N = 252 Age: 11–12 years	N = 1	- Before the programming curriculum began, the cooperative attitude scale of programming was used to test and collect students' basic information - After 10 weeks of the curriculum, students completed a questionnaire on cooperative attitudes, learning styles, self-regulation ability, and enjoyment	*mBlock* was a mobile program where students could use the arrow keys on the keyboard to control mBot's movement and adjust its speed	Computer science

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Study no.	Student participants	Teacher participants	Research design/Method	Game	Subject
			level of programming before taking the computational thinking test		
22	N = 69 (f: 32, m: 37)	N = 2	- A quasi-experimental design and mixed methods data collection were used in this study. Data sources included pre- and posttest and semi-structured interviews	*E-game* was an online role-playing game that included several themed islands, such as English Island, Coding Island, and Science Island	Science
	Age: 12–13 years		- Students were divided into two groups. The experimental group learned based on the gamification, assessment, modeling, and enquiry (GAME) model, while the comparison group learned following traditional learning methods		
23	N = 140	N = Not specified	- A quasi-experimental design was used in this study. Data sources included pre- and posttests and recorded logs	*Machinarium* was a five-level puzzle adventure game	Not specified
	Age: 6th graders		- Students were divided into three groups. The first group played a puzzle adventure game, the second was trained by solving reasoning problems on paper, and the third did not receive any treatment		
24	N = 305 Age: 3rd graders	N = Not specified	- This study used design-based research. - Data sources included usage period data, observations, focus group interviews with students and teachers, and a final science assessment test	*SamEx* was a mobile learning system aiming to support students' self-directed and collaborative learning activities	Science

Appendix C. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.edurev.2023.100546.

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