The University of Tehran Press

Journal of Cognitive Science Research

2025, 1(4), 70-90

Home Page: https://jcsr.ut.ac.ir/

Online ISSN: 3092-6777

Design Features of Educational Games to Foster Metacognitive Skills: A Systematic Review

Maryam Golbaghi [1], Raha Abedi [2*]

1. Department of Cognitive Sciences, Faculty of Psychology and Education, University of Tehran, Tehran, Iran.
2. Department of Methods, Educational Planning, and Curriculum, Faculty of Psychology and Education, University of Tehran, Tehran, Iran.

Corresponding Author: Assistant Professor, Department of Methods, Educational Planning, and Curriculum, Faculty of Psychology and Education, University of Tehran, Tehran, Iran. Email: Raha.abedi@ut.ac.ir

ARTICLE INFO

Article type:
Review Article

Article History:
Received: 13 Oct 2025
Revised: 03 Nov 2025
Accepted: 29 Nov 2025
Published: 31 Dec 2025

Keywords:
Educational Games; Game Design; Game-Based Learning; Metacognition; Metacognitive Skills.

ABSTRACT

This systematic review sought to identify and synthesize the key features of educational games that effectively promoted metacognitive skills. Given the pivotal role of metacognitive skills in self-regulated learning and academic achievement, understanding the game features that can enhance these skills is particularly significant. A comprehensive search was conducted across Iranian and international databases including Scopus, Web of Science, ScienceDirect, Google Scholar, IranDoc, and NoorMags for studies published between 2015 and 2025. Following PRISMA-based screening procedures, 15 eligible empirical studies were included. A qualitative content analysis approach was employed, and the methodological quality of the studies was evaluated using the MMAT (2018 version). The synthesis of findings revealed several core themes that collectively contributed to the activation of metacognitive skills such as planning, monitoring, evaluation, reflection, and self-regulation. These themes encompassed the platform and mode of gameplay, game objectives, game mechanics, game dynamics, aesthetic elements, scaffolding strategies, and the types of feedback embedded within the games. The results indicated that the most effective metacognitive games were those offering an optimal level of challenge, providing immediate and socially mediated feedback, fostering interaction and collaborative dialogue, and balancing excitement, cognitive engagement, and aesthetic appeal—while simultaneously granting learners autonomy and control over their learning experience. Nonetheless, methodological limitations such as heterogeneity in game types, small sample sizes, and reliance on self-reported measures were noted across the reviewed studies. The findings offer practical insights for designers and researchers developing game-based interventions aimed at enhancing metacognitive skills.

Cite this article: Golbaghi, M., & Abedi, R. (2025). Design Features of Educational Games to Foster Metacognitive Skills: A Systematic Review. *Journal of Cognitive Science Research*, *1*(4), 70-90. doi:10.22059/jcsr.2025.407045.1029

Publisher: University of Tehran Press
DOI: https://doi.org/10.22059/jcsr.2025.407045.1029

Introduction

In today's educational environments, merely acquiring knowledge is no longer sufficient for success because learners face an overwhelming volume of information and increasingly complex tasks. For many learners, the main challenge does not lie in a lack of knowledge but in their inability to manage their own learning processes, plan effectively, maintain attention, and evaluate their performance (Azevedo & Cromley, 2004). These challenges are particularly pronounced in open and self-directed learning environments, where they impose a higher cognitive load and require the simultaneous engagement of both cognitive and metacognitive skills (Azevedo & Witherspoon, 2009).

In recent decades, however, games have evolved beyond mere entertainment to become a powerful tool for fostering active and meaningful learning. Unlike traditional educational settings, which rely on the passive transmission of knowledge, game-based environments emphasize learning through experience, receiving feedback, and continuously refining performance (Garris et al., 2002). By providing opportunities for interaction, exposure to incremental challenges, and ongoing decision-making, these environments actively engage learners in the learning process and enhance their intrinsic motivation for exploration and critical thinking (del Moral Pérez et al., 2018).

Beyond purely cognitive aspects, games can create an environment in which learners not only practice skills like problem-solving and decision-making but also regulate and monitor their own mental processes a phenomenon known as metacognition, which refers to the awareness and conscious control of one’s own thought processes (Flavell, 1979). Research suggests that key features of educational games, such as complex scenarios, immediate feedback systems, and opportunities for constructive failure, could offer a fertile ground for practicing metacognitive components including planning, monitoring progress, and evaluating and refining strategies (Plass et al., 2015).

The advancement of digital technologies has further facilitated the creation of self-directed learning environments. These environments help learners monitor and improve their metacognitive skills through mechanisms such as self-explanation and personal reflection. By separating metacognitive instruction from purely educational content, these tools shift active control of the learning process to the learner (Braad et al., 2022).

However, differences in game design including learning objectives, types of interaction, feedback methods, and challenge levels can result in divergent learning outcomes. Some existing gamification frameworks have limited game elements to specific contexts, and a comprehensive, standardized definition that clearly explains how these elements influence different learner behaviors has yet to be established (Baniamerian & Esmaeeli, 2022).

This gap highlights the need to identify and compare the design features of educational games to determine the most effective combinations of game elements for developing metacognitive skills. Consequently, a systematic review of the existing literature is warranted. Such a review would identify and analyze the key design elements of games that enhance metacognitive skills, thereby facilitating the design and implementation of theory-based, game-driven educational interventions.

Metacognition and Its Impact on Learning

The significance of metacognition is well-documented in the literature. The concept of metacognition was first introduced by Flavell (1979) and refers to an individual's knowledge and awareness of their own cognitive processes, as well as their ability to monitor and control them. This framework of metacognition generally encompasses two main dimensions:

1. Metacognitive knowledge: knowledge about mental processes, learning strategies, and the conditions under which learning occurs.
2. Metacognitive regulation: processes such as planning, monitoring, and evaluating performance

during learning.

Research has shown that learners with stronger metacognitive skills tend to perform more effectively, flexibly, and deeply in their learning processes (Braad et al., 2022). These skills play a key role in self-regulated learning, problem-solving, and the transfer of knowledge to new situations (Dignath et al., 2008). Furthermore, previous studies indicated that metacognitive awareness serve as a predictive factor for academic success (Özçakmak et al., 2021). Therefore, metacognitive training is increasingly recognized as an effective approach to enhancing the quality of learning.

Educational Games as a Platform for Developing Metacognitive Skills

In recent years, researchers in the fields of education and learning technologies have argued that educational games offer a suitable platform for practicing and developing metacognitive skills (Kim et al., 2009). Games often present dynamic, problem-based situations in which players must plan, make decisions, adjust their strategies, and evaluate the outcomes of their choices. This cycle closely mirrors the processes of metacognition within an interactive environment (Gee, 2003).

In classical literature, game is defined as an activity in which individuals strive to achieve specific goals but proceed only along paths defined by the rules of the game, with acceptance of these constraints being a prerequisite for the activity to qualify as game (Suits, 1967). More recent sources describe games as structured systems of rules, goals, and player interaction, ranging from highly rule-bound to free-form and improvisational experiences (Fernández-Vara, 2019).

An educational game is an interactive, rule-based environment that actively engages learners in the learning process by purposefully integrating game elements and learning objectives (Plass et al., 2020). According to Plass et al. (2015), the design of educational games is based on several key components, including game mechanics, visual aesthetic design, narrative, motivational systems, music, and educational content. These elements collectively shape the learning experience, with each playing a distinct role in engaging the learner. According to the *Game-Based Learning Handbook* (Plass et al., 2020), in educational games, game mechanics (repetitive actions performed by the learner) are intentionally aligned with learning mechanics (activities designed to achieve educational objectives).

Based on the theoretical framework of Plass et al. (2020), as applied by Dever et al. (2024), "game mechanics" refer to the rules and mechanisms that shape the learner's repeated interactions with the game environment. These mechanics essentially represent the intersection between "instructional methods," which aim to facilitate learning, and "game design elements," which are intended to enhance engagement. When explicitly aligned with metacognitive objectives, such as planning, monitoring, and reflection, they allow for the observation and assessment of learners' metacognitive skills (Braad et al., 2020).

In contrast, "game dynamics" refer to the behavioral patterns and experiences that emerge when players interact with the mechanics, such as collaboration, competition, and peer feedback (Hofbauer & Sigmund, 2003). These dynamics provide the context for the actual activation of metacognitive skills. For instance, group discussion and collective decision-making can foster collaborative planning and reflection (Braad et al., 2020). Consequently, effective game design must create not only well-defined mechanics but also purposeful dynamics that reinforce feedback, inquiry, and reflection (Braad et al., 2020). Mechanics can be seen as the architectural blueprint of the game, while dynamics constitute the actual behavior and life within that structure. Effective game design ensures that players receive immediate feedback throughout their learning journey, enabling them to monitor and adjust their strategies. The narrative and story elements of a game can foster emotional and cognitive engagement, directing players' attention to their own thought processes (McGonigal, 2011).

However, despite the remarkable growth of research on educational games, evidence suggests that most studies have focused on the overall effectiveness of games on academic performance, while paying less attention to design features that specifically target metacognitive skills (Zirawaga et al., 2017).

Furthermore, many studies have focused on the overall effectiveness of games rather than on how to design them effectively (Clark et al., 2016; Mayer, 2014). However, it remains unclear which specific game design elements such as the degree of player agency, the presence of social interaction, the provision of immediate feedback, difficulty levels, or competitive structures are more effective in fostering metacognitive components.

The qualitative review by Braad et al. (2020) is considered one of the first efforts to provide a comprehensive picture of the role of metacognition in game-based learning. By analyzing 24 studies, they identified nine types of metacognitive interventions in digital game environments and argued that educational game design should be developed with explicit consideration of these interventions and the extent to which they are integrated into gameplay. However, their review was limited to digital environments and did not examine the game design features that could enhance metacognition across both digital and non-digital contexts. Moreover, the review was conducted qualitatively and lacked a systematic structure for source selection and evaluation.

Other limited reviews, such as the study by Wouters et al. (2013), have examined the use of games for teaching cognitive skills; however, reviews specifically focusing on the design features of games that enhance metacognition remain scarce. Furthermore, in the Iranian research landscape, most studies including the systematic review by Baniamerian and Esmaeeli (2021) have addressed the general impact of educational games on learning, with limited attention to metacognitive mechanisms. This situation indicate that a comprehensive and systematic understanding of the design features influencing metacognition is still lacking.

Therefore, the present review was conducted systematically, based on standard systematic review guidelines, with the aim of updating previous findings and examining the design features of games that promote metacognition. A systematic review approach was employed to extract and categorize common components in the design of both physical and digital games through the analysis and comparison of empirical research findings. The main research question is formulated as follows:

What are the key features and elements of games that are effective in enhancing metacognitive skills?

Method

Search Strategy

For this systematic review, a comprehensive search of both international and domestic databases was conducted to identify all relevant empirical studies on educational game design and metacognitive skills. The databases searched included Scopus, ScienceDirect, Google Scholar, Web of Science, IranDoc, and NoorMags. The systematic search was carried out between September 18 and September 24, 2025. An updated search was also conducted on October 1, 2025, to ensure the inclusion of the most recent studies published up to that date. The search strategy was designed using a combination of Boolean operators (AND/OR) and a set of English and Persian keywords to ensure that the search process remained both comprehensive and precise. The English keywords included the following phrases, which are presented in Table 1. Persian equivalents were also used in searches of domestic databases.

Table 1. List of Keywords and Boolean Combinations Used in the Search.

OR		OR		OR
game mechanic game dynamics game feature game design game element game component	AND	game digital game serious game educational game board game card game	AND	metacognition metacognitive skills metacognitive awareness

The search terms were combined using Boolean operators to identify studies that directly addressed the role of games in the development of metacognitive skills. For example, the following combinations were used:

("game design" OR "game mechanics" OR "game elements") AND ("metacognition" OR "metacognitive skills")

The search also was limited to the period from 2015 to 2025 to focus on the most recent research over the past decade. Furthermore, only empirical studies and open-access articles were included to ensure that the data were fully analyzed.

Eligibility Criteria

For this systematic review, only studies meeting the following criteria listed in Table 2 were included in the analysis.

Table 2. Inclusion and exclusion criteria for studies in this systematic review.

Inclusion Criteria	Exclusion Criteria
Empirical studies involving an intervention, the implementation of a game, or measurement of a game's effect on cognitive or metacognitive skills.	Theoretical or review studies without empirical data or insufficient methodological data.
Published between 2015 and 2025.	Published before 2015.
Focused on development of metacognitive skills or related components.	Focused only on general learning or motivation without metacognitive components
Published in Persian or English.	Published in languages other than Persian or English.
Not limited to specific clinical populations	Focused on specific clinical populations.
Open-access.	Unavailable full text.

Study Selection and Screening

During the full-text screening phase, 32 initially eligible studies were thoroughly assessed. Of these, 17 were excluded due to insufficient empirical data, a lack of direct focus on metacognition, or unavailability of the full text. Consequently, 15 studies were selected as the final corpus for analysis. EndNote 20 was used to manage references and organize the included articles.

This process was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The study selection followed the PRISMA protocol across four stages: identification, screening, eligibility assessment, and final inclusion (Page et al., 2021).

During the initial identification stage, a total of 4,700 records were retrieved from the Scopus, ScienceDirect, Web of Science, Google Scholar, IranDoc, and NoorMags databases. After removing duplicates, the titles of the remaining articles were screened for relevance to the research question.

In the second stage (preliminary screening), 4,538 records were excluded due to irrelevance to the topics of metacognition and games. During the subsequent abstract review, an additional 130 articles were set aside as they did not focus on metacognitive skills or game design.

In the third stage (full-text review), the full texts of 32 potentially eligible studies were thoroughly assessed. Of these, 17 were excluded due to insufficient empirical data, lack of direct focus on metacognition, or unavailability of the full text.

Ultimately, 15 studies were selected as the final corpus for analysis. These articles originated from various countries and encompassed a range of approaches involving digital, card-based, and physical (in-person) games. A flowchart detailing the study selection process is presented in Figure 1.

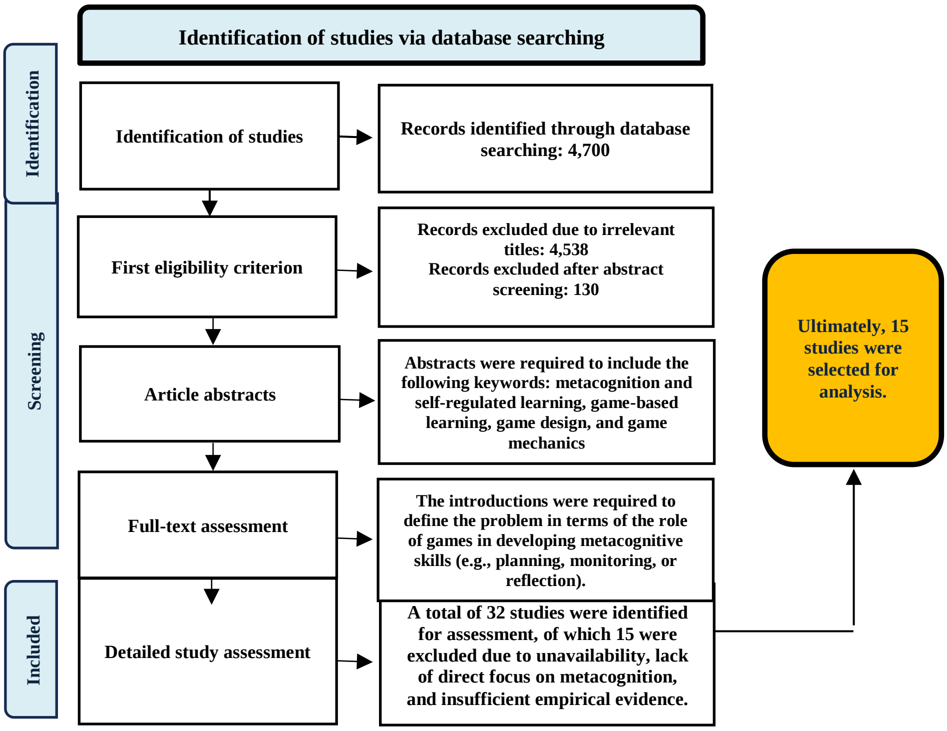

Figure 1. PRISMA flow diagram of the study selection process.

Data Extraction

For the content analysis of the selected studies, key information from each article was first summarized in a table. This table included the author(s) and year of publication, country, sample size, game type and implementation mode, game design features, and findings related to metacognitive skills. It served as the basis for coding and identifying common patterns across the studies.

The coding process was conducted using a qualitative content analysis approach. In the initial stage, a preliminary framework for data categorization was developed based on theoretical concepts of metacognition, such as planning, monitoring, evaluation, self-reflection, and strategy adjustment. Subsequently, while reviewing the study findings, new codes that emerged directly from the data—such as progressive challenge, immediate feedback, or group interaction—were added in an open manner to ensure comprehensive analysis.

In the next stage, similar codes were grouped into conceptual categories. Specifically, the data were analyzed along a main axis focusing on the design features of the games, including challenge structure, type of feedback, degree of player autonomy and decision-making, social interaction, narrative elements, reward systems, and implementation mode (individual or group-based).

To enhance the credibility of the analysis, the data were reviewed and compared iteratively to ensure consistency in coding and coherence across categories. Finally, common patterns across games and metacognitive skills were extracted as key themes. In the results section, these themes and their relationships with metacognitive components are reported in detail.

Quality Assessment

To assess the methodological quality of the studies included in the systematic review, the Mixed Methods Appraisal Tool (MMAT 2018) was used (Hong et al., 2018). This version is specifically designed for reviews encompassing a combination of qualitative, quantitative, and mixed-methods studies, facilitating coherent comparison and analysis of research quality. The MMAT 2018 includes two initial screening questions and five methodological criteria specific to each study design. In this study, to ensure a comprehensive appraisal, all criteria were applied to every study. Thus, the two screening questions (pertaining to the clarity of the research questions and the appropriateness of the methodology), along with the five design-specific criteria (for qualitative, quantitative, or mixed-methods designs), were considered.

The MMAT scores were used solely to describe the methodological quality of the studies and to facilitate accurate interpretation of the evidence, rather than to exclude or weight studies. In line with the MMAT authors' recommendations (Hong et al., 2018), the final discussion focused on a qualitative analysis of each study's methodological strengths and weaknesses, considering limitations such as inadequate reporting of sampling or data analysis. The details of each study's scoring according to the MMAT criteria are provided in Tables 5–9 in the appendix.

Results

To describe the general characteristics of the studies included in the systematic review, Table 3 presents information on the authors, year of publication, country, sample size, research method, source of publication and methodological quality score based on the MMAT 2018 tool.

Table 3. General characteristics and methodological quality of the studies included in the systematic review.

Authors & Year	Country	Sample size	Journal	Study Design	MMAT Score
Chatzipanteli et al. 2015	Greece	71	American Journal of Educational Research	Mixed-methods	80%
Snow et al. 2015	USA	76	Proceedings of the 7th International Conference on Educational Data Mining	Quantitative – Descriptive	60%
Braad et al. 2019	Netherlands	7	Proceedings of the 13th International Conference on Game Based Learning (ECGBL 2019)	Mixed-methods	60%
Safay Honarvari & Moshkbid Haghighi 2019	Iran	30	Quarterly Journal of Child Mental Health	Quantitative – Non-randomized	60%
Fishovitz et al. 2020	USA	89	Journal of Chemical Education	Mixed-methods	60%
van Heereveld 2020	Netherlands	35	MSc Thesis, University of Groningen	Mixed-methods	60%
Toh & Kirschner 2020	Singapore	6	Computers & Education	Qualitative	100%
Stephanou & Karamountzos 2020	Greece	41	Research in Psychology and Behavioral Sciences	Quantitative – Non-randomized	70%
Beik 2020	Iran	30	MAc Thesis in Physical Education, Urmia University	Quantitative – Randomized Controlled Trial	80%
von Gillern & Stufft 2022	USA	31	Literacy	Qualitative	100%
Takada et al. 2023	Japan	20	JASAL Journal	Mixed-methods	60%
Wilson et al. 2023	Malaysia	25	Asian Journal of University Education (AJUE)	Qualitative	100%
Shaheen & Fotaris 2024	United Kingdom	210	The Proceedings of the 19th European Conference on Games Based Learning	Mixed-methods	70%
Çiftci & Yıldız 2024	Turkey	40	International Journal of Computers in Education	Quantitative – Non-randomized	80%
Raees Dehghan 2024	Iran	120	MAc Thesis in Educational Science, Farhangian University	Quantitative – Non randomized	80%

A systematic analysis of the studies included in this review revealed that, although the examined games differed in nature, platform (digital vs. physical), and target audience, they all employed a common set of design principles aimed at supporting learning and enhancing metacognitive skills. Coding and comparative analysis of the studies led to the identification of several key interrelated dimensions, each playing a distinct role in activating metacognitive skills. These dimensions included game platform and procedure, objectives, mechanics, dynamics, aesthetic elements, pacing patterns, and feedback mechanisms (Figure 2).

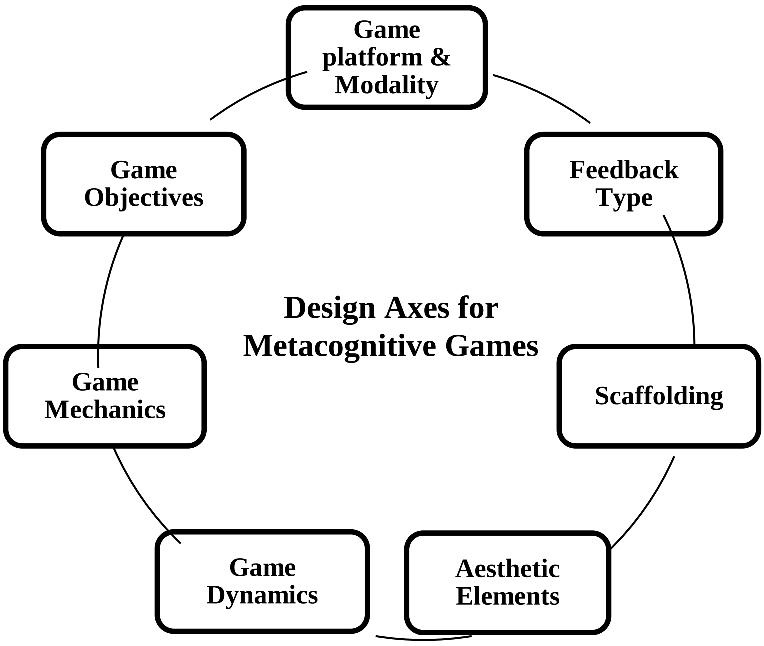

Figure 2. Core design axes identified across metacognition-enhancing educational games.

Game Platform and Modality

Analysis of the studies indicate that metacognitive games are implemented in two main settings group and individual—across both physical and digital platforms, promoting distinct mechanisms for enhancing metacognition.

1. Group-Based Games

This category leverages direct social interaction to foster collective reflection, articulation of reasoning, and evaluation of diverse perspectives. Card games such as *Guided Heads-Up* and *Smarties* are implemented in classroom settings with small groups and the need to provide clues, engage in discussion, and persuade teammates directly promotes self-evaluation and reflective thinking (Fishovitz et al., 2020; Takada et al., 2023).

In sports environments, interventions based on the Teaching Games for Understanding (TGfU) approach in basketball (Stephanou & Karamontzos, 2020; Chatzipanteli et al., 2015) and futsal (Beik, 2020) employ group-based game design emphasizing tactical problem-solving, leading to improved planning and decision-making. Teacher questioning in these contexts plays a pivotal role in activating metacognitive Skills.

Digital games such as *Minecraft* (von Gillern & Stufft, 2022) and *The Sims 4* (Wilson et al., 2023) are also played in multi-person groups. Interaction within these virtual environments facilitates collective reflection on the learning process and the development of conditional metacognitive knowledge knowing why and when to use a particular strategy.

2. Individual-Based Games

These games are predominantly digital and provide a safe space for practicing self-regulation, personal planning, and self-monitoring. Games such as *MeCo* (Braad et al., 2019) and *The Mend* (Shaheen & Fotaris, 2024) are played individually on web or mobile platforms. By simulating the self-regulated learning cycle and incorporating planned reflective pauses, these games enhance emotional self-awareness and planning skills.

The *Learn2Conquer* application (van Heereveld, 2020) and the Scratch programming environment (Çiftçi & Yıldız, 2024) serve as individual platforms that require users to predict, test, debug, and iterate. This process constitutes a rich metacognitive activity that directly contributes to increased metacognitive awareness and skills.

Game Objectives

Analysis of the selected studies reveal that games designed to enhance metacognition have highly specific objectives compared to purely entertainment-focused games. These objectives can be categorized as follows:

1. Explicitly Promoting Reflective Thinking and Self-Assessment

Many games explicitly list reflective thinking, self-assessment of knowledge, and self-awareness as primary goals. For instance, *Guided Heads-Up* is designed to promote metacognition and self-assessment of learning (Fishovitz et al., 2020). Similarly, *The Mend*, which employs the Reflective Game Design (RGD) framework, aims to enhance emotional resilience, self-awareness, and critical thinking (Shaheen & Fotaris, 2024). The card game *Smarties* is also developed to enhance reflective thinking about language learning strategies (Takada et al., 2023).

2. Direct Practice of Metacognitive Skills and Strategies

Some games focus on practicing and implementing the metacognitive cycle (planning, monitoring, and evaluation). For example, *Learn2Conquer* is designed to increase motivation and repeatedly practice metacognitive skills through goal design, planning, activity execution, reflection, and reward (van Heereveld, 2020). The digital game *MeCo* similarly aims to increase metacognitive awareness through exploratory missions (Braad et al., 2019). Çiftçi and Yıldız (2024) also emphasize practicing metacognitive strategies through Scratch-based game design to enhance metacognitive awareness and mathematics achievement.

3. Creating Problem-Solving Environments to Elicit Metacognition

Games in this category simulate complex, non-routine situations whose resolution requires metacognitive engagement. For instance, in the TGfU approach in physical education, basketball and futsal games aim not merely to score points but to solve tactical problems during gameplay, compelling students to plan, monitor, and evaluate their strategies (Stephanou & Karamountzos, 2020; Chatzipanteli et al., 2015). Similarly, *The Sims 4*, with its retail store management goal, provides an environment for eliciting planning, monitoring, and evaluation (Wilson et al., 2023).

4. Enhancing Foundational Executive and Metacognitive Skills

Studies involving younger children focus on strengthening foundational metacognitive skills. For example, Safay Honarvari and Moshkbid Haghighi (2019) use rhythmic games to enhance planning, organization, and metacognition in preschoolers. Raees Dehghan (2024) also aims to strengthen metacognitive skills (self-awareness, goal-setting, self-regulation, problem-solving) through elementary school games.

5. Facilitating Self-Directed and Exploratory Learning

Some games create open, rich environments that foster self-directed learning. Toh and Kirschner (2020) show that narrative-exploration games like *The Last of Us* and *Mass Effect* provide an environment for self-directed learning and reflection, naturally challenging players' metacognition.

6. Stealth Assessment of Metacognitive Skills

Finally, some studies focus on the indirect and hidden assessment of metacognition. Snow et al. (2015), analyzing behavioral patterns in the game-based environment *iSTART-2*, seek to stealthily assess learner agency and self-regulation through metrics such as entropy, representing a novel approach to evaluating metacognition.

Game Mechanics

Analysis of the data obtained from coding the studies revealed that a variety of game mechanics were employed in the reviewed games, each of which contribute to the enhancement of metacognitive components in distinct ways. These mechanics can be classified into several broad categories:

1. Dialogue-, Choice-, and Reasoning-Based Mechanics

In *Guided Heads-Up*, mechanics such as providing clues from general to specific using technical language and correcting mistakes by teammates compel participants to actively evaluate and revise their knowledge, thereby strengthening self-assessment and error correction (Fishovitz et al., 2020). In *Smarties*, mechanics such as selecting a strategy from a set of cards for a learning situation and subsequently explaining the reasoning for their choice within the group prompt players to select appropriate strategies and reflect on their own learning processes (Takeda et al., 2023). In *MeCo*, the binary choice mechanic, implemented via dragging cards left or right within a dynamic narrative, engages players in the cycle of planning, execution, and evaluation (Braad et al., 2019).

2. Design-, Construction-, and Problem-Solving Mechanics

Çiftçi and Yıldız (2024) demonstrate that fundamental block-based programming mechanics in Scratch, such as movement control, using conditional statements (if…then), and implementing mathematical calculations, naturally immerse students in the processes of prediction, planning, monitoring, and debugging, all of which are key components of metacognition. In the video games reviewed by Toh and Kirschner (2020), mechanics such as solving puzzles, interacting with the environment to find resources, and learning from failure facilitate the emergence of metacognitive strategies, including trial-and-error, reflection, and adaptation.

3. Simulation and Managerial Decision-Making Mechanics

In *The Sims 4: Get to Work*, mechanics such as making decisions regarding store location, pricing, and staff management require students to plan, monitor performance (e.g., sales reports), and evaluate their business strategies, thereby contributing to the enhancement of conditional knowledge (i.e., knowing when and why to use a particular strategy) (Wilson et al., 2023).

4. Gamification Mechanics for Structured Metacognitive Practice

This category of mechanics directly implements metacognitive frameworks within game elements. In the *Learn2Conquer* application, mechanics such as goal setting, using a timer to monitor time, and receiving rewards (gold) for engaging in reflection provide a structured framework for practicing planning, monitoring, and evaluation skills (van Heereveld, 2020).

5. Physical and Kinesthetic Mechanics in Non-Digital Environments

In the TGFU model, mechanics such as modifying rules (e.g., requiring two passes before a shot), reducing the number of players, and defining a tactical problem as the primary objective encourage players to continuously think about the game, find solutions, and evaluate their performance rather than merely executing skills. This leads to improvements in declarative, procedural, and conditional knowledge (Chatzipanteli et al., 2015; Stephanou & Karamountzos, 2020). Rhythmic games, through mechanics such as following the coach's instructions and motor coordination with rhythm, contribute to the enhancement of executive functions and metacognition in children by improving motor planning and organization (Safay Honarvari & Moshkbid Haghighi, 2019).

6. Agency and Choice Mechanics

Some games promote players' monitoring of their own behavior and planning of their learning path by granting them agency. In the *iSTART-2* system, the free choice mechanic, allowing selection of activities from a main menu, enables researchers to measure users' behavioral entropy as a hidden indicator of self-regulation. Findings indicate that orderly interaction (lower entropy), regardless of the activity type, is associated with higher-quality metacognitive outputs (e.g., self-explanations) (Snow et al., 2015).

Game Dynamics

Furthermore, various dynamics are identified in the games from the selected studies, which can be categorized into three groups:

1. **Social Interaction and Strategic Dialogue**

This dynamic is evident in both in-person and digital group games. In games such as *Guided Heads-Up* (Fishovitz et al., 2020) and *Smarties* (Takada et al., 2023), discussions and exchanges aimed at selecting the best strategy or clue, as well as in TGfU environments in physical education (Stephanou & Karamountzos, 2020; Chatzipanteli et al., 2015), where dialogues about tactics occur, compel players to revise knowledge, reason, and evaluate others' perspectives. This directly strengthens metacognitive reflection and evaluation skills.

2. **Action–Feedback–Adjustment Cycle**

This fundamental cycle is observed in design-based learning environments (such as Scratch;

Çiftçi & Yıldız, 2024) and digital games (such as *iSTART-2*; Snow et al., 2015, and *Learn2Conquer*; van Heereveld, 2020). In this model, through mechanisms such as trial and error, debugging, receiving immediate feedback (points, rewards, game status), and subsequently adjusting their strategies, players are continuously engaged in monitoring their progress and evaluating the effectiveness of their performance.

3. Reflective Pauses and Self-Regulation

Some games, such as *The Mend* (Shaheen & Fotaris, 2024), incorporate planned pauses for reflection (e.g., journaling or answering metacognitive questions), and rhythmic games (Honarvari & Moshkbid Haghighi, 2019) require coordination, attention, and response inhibition. Both approaches directly target self-awareness, inhibition, and self-regulation. Overall, these dynamics create challenging, interactive, and adaptive environments that provide a natural context for the frequent activation and reinforcement of key metacognitive components.

Aesthetic Elements

Analysis of the studies indicates that the aesthetic elements of the games can be categorized into several general patterns, each contributing to the enhancement of metacognitive components. These patterns are:

1. Simplicity and Minimalism for Content Focus and Interaction

These games utilize simple designs, devoid of complex elements, to fully direct the player's attention toward the targeted cognitive and metacognitive skills. *Guided Heads-Up* (Fishovitz et al., 2020), with simple printed cards, and *The Mend* (Shaheen & Fotaris, 2024), with a minimalist user interface, minimize distractions and provide a space for deep thinking and reflection. Similarly, the *Learn2Conquer* application (van Heereveld, 2020) features a simple, color-coded interface designed primarily to reduce extraneous cognitive load and focus attention on planning and reflection.

2. Simulation and Visual Metaphors for Visualizing Abstract Concepts

These games employ visual metaphors to concretize and facilitate understanding of internal mental processes such as emotion regulation, problem-solving, and planning. *The Mend* (Shaheen & Fotaris, 2024) uses the visual metaphor of home renovation to represent the restructuring of emotions and critical thinking. In *The Sims 4* (Toh & Kirschner, 2020), realistic simulated graphics and visual cues (e.g., employee wellness status) allow students to observe the consequences of their decisions in a safe, concrete environment, which strengthens their metacognitive conditional knowledge (i.e., knowing when and why a strategy is effective).

3. Storytelling and Emotional Immersion for Creating Deep Engagement

The games examined by Toh and Kirschner (2020), including *The Last of Us* and *BioShock*, leverage strong narratives, realistic and emotional environments, and music to evoke profound cognitive and emotional responses in players. This engagement encourages players to think critically, engage in moral reasoning, and reflect on their choices. *MeCo* (Braad et al., 2019) similarly uses a sci-fi setting and humorous narrative to create an engaging space for metacognitive exploration.

Scaffolding

Based on evidence from the studies included in this review, scaffolding patterns in metacognition-enhancing games can be classified into four main categories:

1. Hierarchical Pattern

This pattern is characterized by a gradual increase in complexity and the step-by-step presentation of content. For example, in the TGFU approach, games progress from simple to more complex situations (Chatzipanteli et al., 2015; Stephanou & Karamountzos, 2020). Similarly, rhythmic game sessions are designed hierarchically (Honarvari & Moshkbid Haghighi, 2019).

2. Cyclical Pattern

This pattern is organized around cycles of action and reflection. *MeCo* utilizes a three-stage cycle comprising forethought, performance, and reflection (Braad et al., 2019). Likewise, *The Mend* incorporates planned reflective pauses to support iterative thinking (Shaheen & Fotaris, 2024).

3. Structured Pattern

This pattern relies on a pre-defined sequence to guide thinking. In *Guided Heads-Up,* clues are provided from general to specific (Fishovitz et al., 2020). In the Scratch environment, teacher guidance and peer feedback are incorporated to provide additional structure (Çiftçi & Yıldız, 2024).

4. Free-Form Pattern

This pattern emphasizes learner agency and freedom in choosing activities. In the *iSTART-2* system, players are able to freely select the sequence of activities (Snow et al., 2015). In narrative games, branching choices enable personalized sequencing tailored to individual players (Toh & Kirschner, 2020).

Feedback Patterns

Based on analyses of the selected studies, feedback patterns in games designed to enhance metacognitive components are divided into two main categories:

1. Social Feedback

One of the most frequently used types of feedback in metacognitive games, social feedback typically occurs through interpersonal interactions in group settings. Examples include peer feedback during discussions and exchanges aimed at selecting the best strategy in *Guided Heads-Up* (Fishovitz et al., 2020) and the card game *Smarties* (Takada et al., 2023), as well as teacher facilitation during the feedback process (Fishovitz et al., 2020). Another form of social feedback involves the use of leaderboards to create competitive motivation (van Heereveld, 2020).

2. In-Game Feedback

This type of feedback is provided immediately during the player's interaction with the game environment. Examples include visual, auditory, and animated cues in *The Mend* (Shaheen & Fotaris, 2024), controller vibration in video games (von Gillern & Stufft, 2022), and reward-based feedback such as points, leveling up, or achievements in the *Learn2Conquer* application (van Heereveld, 2020)

To identify common patterns between game design and metacognitive components, key characteristics of each study including the game's name and type, implementation method, design elements, targeted metacognitive components, and main results—are summarized in Table 4. This table serves as the basis for qualitative analysis and the development of main themes in the findings section.

Table 4. Summary of key study features related to game design and metacognitive components.

Authors & Year	Game Title and Mode of Play	Key Game Features	Targeted Metacognitive Skills	Main Metacognition-Related Findings
Chatzipanteli et al. 2015	Basketball (TGFU) In-person – Group	Reducing player numbers/ smaller play area/ focus on tactical objectives/ interaction with coach.	Declarative knowledge, procedural knowledge, conditional knowledge	The experimental group scored higher on the metacognition questionnaire, with qualitative analysis showing enhanced tactical problem-solving, analysis, monitoring, and evaluation.
Snow et al. 2015	iSTART-2 Digital – Individual	Personalized responses to content/ identifying instructional strategies/ customizable interface/ progress tracking/ self-directed learning.	Self-regulation, behavioral monitoring and planning, behavioral control in choices, monitoring and evaluation	Lower behavioral entropy in the game environment indicating better self-regulation was linked to metacognitive success.
Brad et al. 2019	MeCo Digital – Individual	Humorous, dynamic narrative/ selectable learning goals/ self-regulated learning cycle/ sci-fi with cartoon characters.	Planning, monitoring, self-regulation, and evaluation of learning	The game was engaging but did not increase metacognitive awareness or transfer skills to real-world contexts.

Safay Honarvari & Moshkbid Haghighi	Rhythmic Games In-person – Group	Rhythmic, synchronized movements/ group coordination/ responding to auditory and visual stimuli.	Planning, organizing	Rhythmic games significantly improved children's metacognitive skills (planning and organizing) and related executive functions.
Fishovitz et al. 2020	Guided Heads-Up In-person – Group	Sequential clues/ use of technical language/ general-to-specific & high-to-low thinking/ collaboration/ peer error correction.	Self-assessment of knowledge, error correction, reflection, prioritization of information, awareness of learning processes	The game supported self-knowledge assessment and increased student engagement and understanding.
van Heereveld 2020	Learn2Conquer (L2C) Digital – Individual	Reward system/ equipment upgrades/ learning strategies via victories/ leaderboard/ timer/ gradual difficulty.	Planning, monitoring, evaluation	The game did not significantly enhance metacognitive awareness but fostered initial motivation.
Toh & Kirschner 2020	The Last of Us Mass Effect The Walking Dead Bioshock Digital – Individual	Exploration for resources, hidden paths, and clues/ dialogue with NPCs/ moral decisions/ puzzles/ learning from feedback/ free decision-making.	Planning, evaluation, and strategy adjustment	Players employed metacognitive strategies (planning, evaluation, strategy adjustment) and emotional regulation for self-directed learning during challenges.
Stephanou & Karamountzos 2020	Basketball (TGFU) In-person – Group	Simplified rules / focus on passing, dribbling, shooting/ group cooperation/ tactical problem-solving/ teacher feedback.	Metacognitive knowledge (declarative, procedural, conditional, information management) and metacognitive regulation (planning, monitoring, problem-solving, evaluation, mental visualization)	The TGFU approach enhanced metacognitive knowledge and regulation abilities.
Beik 2020	Futsal Game Practice (TGFU) In-person – Group	Modifying player numbers/ rule and scoring adjustments/ individual constraints for balance.	Planning, self-monitoring, performance evaluation, information management	The experimental group showed significant improvements in metacognitive behavior, performance, decision-making speed, and accuracy.
von Gillern & Stufft 2022	Minecraft, Story Mode LEGO Worlds Zoo Tycoon Digital – Group	Building and resource gathering/ combat and survival/ group collaboration/ symbol-based decisions/ open-world exploration/ dynamic events.	Self-regulation, planning, comprehension monitoring, metacognitive reflection	Games clearly promoted metacognition; students demonstrated self-reflective behaviors.
Takada et al. 2023	Smarties In-person – Group	Strategy cards for hypothetical scenarios/ reveal and justify reasoning/ group discussion/ persuading others.	Selecting appropriate strategies, monitoring and evaluation, self-regulation	Games strengthened reflective thinking at multiple levels, including linking to real learning, gaining new perspectives, and reflecting on prior knowledge.
Wilson et al. 2023	The Sims 4: Get to Work Digital – Group	Marketing strategies/ financial management/ sales analysis/ customer & employee interaction/ responding to market trends.	Declarative knowledge, procedural knowledge, conditional knowledge, planning, monitoring, evaluation, information management strategies, debugging strategies	Students exhibited 3 types of metacognitive knowledge (declarative, procedural, conditional) and ∘ regulatory processes (planning, information management, comprehension monitoring, error correction, evaluation).

Shaheen & Fotaris 2024	The Mend Digital – Individual	Puzzle solving/ narrative choices/ breathing exercises/ memory logging/ emotion tracking/ character interaction/ reflective pauses/ ethical decisions.	Emotional self-awareness, emotional regulation	The RGD version increased critical thinking, personal reflection, and emotional awareness.
Çiftci & Yıldız 2024	Scratch-Designed Games Digital – Individual	Scratch programming / game rule design / calculations / immediate feedback / interactive scenarios / trial-and-error / debugging / predicting outcomes.	Planning, monitoring, evaluation	The game design process significantly increased metacognitive awareness (mean scores from 31.25 to 65.45) and improved math performance.
Raees Dehghan 2024	Elementary School Games In-person – Group	Physical, imitative, symbolic, imaginative, and rule-based mechanics / cooperation / self-expression / role-play / rule negotiation / exploration.	Self-awareness, self-regulation, problem-solving, behavioral monitoring and evaluation	Elementary school games positively impacted all metacognitive skill components (self-awareness, goal-setting, self-regulation, problem-solving, monitoring, and evaluation).

Discussion and Conclusion

This systematic review was conducted to identify, analyze, and categorize the key design features of educational games both digital and non-digital that were effective in enhancing metacognitive skills. To address the primary research question, "What are the key features and elements of games that effectively enhance metacognitive skills?" empirical studies published between 2015 and 2025 were examined and analyzed, providing a systematic and up-to-date overview of the most effective design elements in this domain.

Analysis of the studies included in this review indicate that in collaborative games, metacognition often manifest in a social form. A key mechanism is "dialogue-driven reflection" a process in which collective decision-making, articulating reasoning, and observing others' strategies enhance cognitive self-awareness (Iiskala et al., 2011). As also shown in other studies, including Iiskala et al. (2015), the findings of this review confirm that requiring players to defend their decisions or evaluate alternative solutions develops their metacognitive skills. Studies such as Chatzipanteli et al. (2015) and Takada et al. (2023) further indicate that group interaction serve as a starting point for cognitive self-evaluation, with gameplay providing a natural context for this social process to occur.

However, a different pathway is observed in individual digital games. Findings from MeCo (Braad et al., 2019) and iSTART-2 (Snow et al., 2015) indicate that a gradual progression of challenges, coupled with continuous feedback, fosters the internalization of skills such as prediction, monitoring, and error correction. In these games, the individual engages in a dialogue with the self a process described by Vygotsky (1978) as inner speech, which plays a crucial role in cognitive self-regulation. From this perspective, digital games can serve as laboratories for practicing cognitive self-regulation, provided their feedback structures are not merely rewarding but also reflective and explanatory.

A central theme that emerges across all studies is the importance of scaffolding and progression in metacognitive development. According to Vygotsky (1978), optimal learning occurs within an individual's zone of proximal development—the gap between what a learner can accomplish independently and what they can achieve with guidance and collaboration. Game designs that progressively increase difficulty create precisely these conditions, enabling learners to tackle more complex challenges by relying on structured support (van Heereveld, 2020; Stephanou & Karamontzus, 2020; Chatzipanteli et al., 2015; Beik, 2020).

Qualitative analysis of the studies reveals that emotions and aesthetic elements in educational games do not merely serve a decorative or motivational role; rather, they function as an integral part of the learning process. In games with strong narratives, metaphors, or artistic design—such as The Mend (Shaheen & Fotaris, 2024)—the creation of meaningful emotional situations contributes to increased cognitive engagement, reflective thinking, and higher-level processing. This approach aligns with neuroscientific evidence on the functional integration of emotion and cognition, particularly the interaction between the prefrontal cortex and the amygdala, which play key roles in regulating attention, decision-making, and learning (Pessoa, 2008).

Another important finding relates to the dynamic interplay between competition and cooperation in the metacognitive experience. Healthy competition, by activating intrinsic motivation and cognitive focus, drives individuals to analyze their errors and strategies more meticulously, whereas cooperation provides opportunities to review situations from others' perspectives and compare different mental models. Integrating both competition and cooperation in games, therefore, can enhance reflection from both internal and external standpoints. This dynamic reflects the patterns observed in studies by Chatzipanteli et al. (2015) and Fishovitz et al. (2020), and can be regarded as a complementary mechanism for fostering both intrapersonal and interpersonal reflection.

An important factor that warrants closer attention is the influence of cultural and contextual variables on both game design and metacognitive outcomes. Educational games are not culturally neutral; learners' perceptions of challenge, feedback, collaboration, competition, and autonomy are shaped by sociocultural norms, educational traditions, and classroom practices (Ordin et al., 2024). For instance, in collectivist cultures, game designs emphasizing collaboration, peer dialogue, and shared problem-solving may more effectively activate socially shared metacognition, whereas in individualistic contexts, autonomy-focused mechanics and self-paced reflection may better support individual metacognitive regulation (Hadwin, Järvelä, & Miller, 2011; Ordin et al., 2024).

The integration of metacognitive features within games is not context-independent but is strongly mediated by the surrounding educational ecosystem. As Dichev and Dicheva (2017) highlight in their critical review of gamification in education, factors such as curriculum constraints, prevailing assessment cultures, teacher readiness and roles, and learners' familiarity with game-based learning fundamentally shape how these features are perceived, adopted, and utilized. Consequently, the effectiveness of metacognitive game design features should be interpreted within the specific cultural and educational contexts in which they are implemented, rather than assumed to be universally transferable .

Despite the documented benefits of metacognition-oriented game design, several practical challenges may constrain the successful implementation of these features in real educational settings. A key challenge lies in the time and resource demands associated with designing, facilitating, and integrating games that incorporate reflective pauses, adaptive feedback, and scaffolding mechanisms within already crowded curricula. Teachers may require additional training to effectively guide metacognitive dialogue, support reflection, and balance gameplay with instructional objectives.

The integration of digital games into formal educational assessment is further complicated by both technological and methodological constraints. Technologically, uneven access to devices, variable software stability, and inconsistent technical infrastructure across educational institutions can impede reliable and equitable implementation (Udeozor et al., 2024). Methodologically, designing and deploying game-based assessments is complex; aligning in-game tasks with specific learning outcomes, extracting meaningful data from player interactions, and interpreting these data to infer competency levels present significant challenges for educators (Udeozor et al., 2024). These difficulties highlight the need for assessment frameworks that are not only pedagogically robust but also pragmatically feasible across diverse classroom contexts .

Finally, the present review indicates that an educational game reaches its highest effectiveness when it focuses not solely on content but on the process of thinking in action. Successful design places the learner in situations where action and reflection are continuously intertwined.

Overall, the analysis of findings reveals that the most effective game designs are those that integrate phased scaffolding with progressively increasing levels of challenge, allowing learners to move gradually from guided engagement toward self-regulation. Effective designs also incorporate immediate, social, or in-game feedback that supports ongoing monitoring and self-evaluation. In addition, games that create opportunities for interaction, reflective dialogue, and collaborative decision-making tend to strengthen metacognitive engagement.

Another important feature is achieving a balance among emotional appeal, cognitive involvement, and aesthetic design, which ensures that the game remains both engaging and purposeful. Finally, providing learners with meaningful choice and agency enhances personalization and encourages deeper strategic thinking.

From a practical standpoint, the results of this review can serve as a valuable guide for instructional designers and cognitive science researchers. By integrating the core components of challenge, feedback, reflection, and scaffolding, they can create games that not only convey knowledge but also cultivate the process of “thinking about thinking” in learners.

Limitation

This systematic review, like any study, has several limitations. First, the search was limited to studies published in Persian and English, which may have introduced language bias and led to the exclusion of valuable research in other languages. Second, the omission of certain studies due to lack of open access may have influenced the final findings. Third, the considerable diversity in game types (digital, physical, card-based) and metacognitive assessment tools made it unfeasible to conduct a quantitative analysis or direct numerical comparison across studies. Finally, due to reporting limitations in some of the included articles, details regarding game design or implementation were not always clear, which affected the transparency of the design element classification. Therefore, the findings of this review should be interpreted in light of these limitations.

Recommendation

Based on the findings of this review, it is recommended that future research employ more rigorous and longitudinal designs to better determine the long-term stability of metacognitive effects fostered by gameplay. More transparent reporting of intervention details, along with the use of multi-method assessment tools—combining self-report measures, observation, and functional performance metrics—would substantially enhance the quality of the evidence. Furthermore, investigating the specific impact of different game mechanics, social dynamics, and scaffolding patterns on distinct components of metacognition (such as planning, monitoring, and evaluation) could contribute to the development of more precise frameworks for educational game design. From a practical perspective, collaboration among game designers, cognitive scientists, and educators is essential to create games that are not only engaging but also intentionally and effectively strengthen metacognitive skills.

Declarations

Author Contributions

The conception and design of the study were developed by M.G and R.A. The database search, data extraction, and qualitative synthesis were conducted by M.G. Supervision, validation, and critical revision of the manuscript were carried out by R.A. Both authors contributed to drafting and revising the manuscript and approved the final version.

Data Availability Statement

The datasets analysed in this review consist entirely of previously published studies, all cited and summarized in the article. Additional information is available from the corresponding author upon request.

Acknowledgements

We extend our heartfelt thanks to the academic community and the authors of the primary studies examined in this review. Their scholarly work and insights into game-based learning and metacognition have been indispensable to the completion of this research.

Ethical considerations

As this study is a systematic review of existing literature, it did not involve any direct interaction with human or animal subjects. All original publications have been appropriately cited, and no ethical approval was required for this study.

Funding

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The work was conducted independently by the authors.

Conflict of interest

The authors hereby state that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The entire research process was conducted with a commitment to integrity and objectivity.

References

Azevedo, R., & Cromley, J. G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia? *Journal of Educational Psychology*, *96*(3), 523–535. https://doi.org/10.1037/0022-0663.96.3.523

Azevedo, R., & Witherspoon, A. M. (2009). Self-regulated learning with hypermedia. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Handbook of metacognition in education* (pp. 319–339). Routledge.

Baniamerian, S., & Esmaeeli, S. (2022). The role of gamification in learning. *Educational Psychology, 17*(62), 107–130. https://doi.org/10.22054/jep.2022.58370.3266

Beik, S. (2020). *The effect of game-based pedagogy on performance, decision making and metacognitive behavior: Play practice approach* [Master's thesis, University of Urmia]. Ganj IranDoc. https://ganj.irandoc.ac.ir/#/articles/9f2b0217eedb72909b6174869f0913a3/fulltext

Braad, E., Degens, N., & Ijsselsteijn, W. (2019). MeCo: A digital card game to enhance metacognitive awareness. In L. Elbaek, G. Majgaard, A. Valente, & S. Khalid (Eds.), *Proceedings of the 13th International Conference on Game Based Learning, ECGBL 2019* (pp. 92–100). Dechema e.V. https://doi.org/10.34190/GBL.19.066

Braad, E., Degens, N., Barendregt, W., & Usselsteijn, W. (2022). Improving metacognition through self-explication in a digital self-regulated learning tool. *Educational Technology Research and Development, 70*(6), 2311–2336. https://doi.org/10.1007/s11423-022-10156-2

Braad, E., IJsselsteijn, W., & Degens, N. (2020). Designing for metacognition in game-based learning: A qualitative review. *Translational Issues in Psychological Science,* 6(1), 53–69. https://doi.org/10.1037/tps0000217

Chatzipanteli, A., Digelidis, N., Karatzoglidis, C., & Dean, R. (2015). Promoting students' metacognitive behavior in physical education through TGFU. *American Journal of Educational Research, 1*(2), 28–36. https://doi.org/10.12691/education-1-2-1

Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of Educational Research, 86*(1), 79–122. https://doi.org/10.3102/0034654315582065

Çiftci, K. G., & Yıldız, B. (2024). Impact of Digital Game Design Using Metacognition Strategies on Math Achievement. *International Journal of Computers in Education,* 7(2), 181–203. https://doi.org/10.5281/zenodo.14583145 del Moral Pérez, M. E. del, Guzmán Duque, A. P., & Fernández García, L. C. (2018). Game-based learning: Increasing the logical-mathematical, naturalistic, and linguistic learning levels of primary school students. *Journal of New Approaches in Educational Research, 7*(1), 31–39. https://doi.org/10.7821/naer.2018.1.248

Dever, D., Wiedbusch, M., Marano, C., Brosnihan, A., Smith, K., Patel, M., Delgado, T., Lester, J., & Azevedo, R. (2024). From product to process data: Game mechanics for science learning. *International Journal of Serious Games, 11*(4), 127–153. https://doi.org/10.17083/jsg.v11i4.790

Dichev, C., & Dicheva, D. (2017). Gamifying education: What is known, what is believed and what remains uncertain: A critical review. *International Journal of Educational Technology in Higher Education, 14*(9), 1–36. https://doi.org/10.1186/s41239-017-0042-5

Dignath, C., Buettner, G., & Langfeldt, H. (2008). How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes. *Educational Research Review, 3*(2), 101–129. https://doi.org/10.1016/j.edurev.2008.02.003

Fernández-Vara, C. (2019). *Introduction to game analysis* (2nd ed.). Routledge. https://doi.org/10.4324/9781351140089

Fishovitz, J., Crawford, G. L., & Kloepper, K. D. (2020). Guided heads-up: A collaborative game that promotes metacognition and synthesis of material while emphasizing higher-order thinking. *Journal of Chemical Education*. Advance online publication. https://doi.org/10.1021/acs.jchemed.9b00904

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & Gaming, 33*(4), 441–467. https://doi.org/10.1177/1046878102238607

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment, 1*(1), Article BOOK01. https://doi.org/10.1145/950566.950595

Hadwin, A. F., Järvelä, S., & Miller, M. (2011). Self-regulated, co-regulated, and socially shared regulation of learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 65–84). Routledge.

Hofbauer, J., & Sigmund, K. (2003). Evolutionary Game Dynamics. *Bulletin of the American Mathematical Society, 40*, 479–519. https://doi.org/10.1090/S0273-0979-03-00988-1

Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.-C., Vedel, I., & Pluye, P. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Education for Information* (Special Issue). https://doi.org/10.3233/EFI-180221

Iiskala, T., Vauras, M., Lehtinen, E., & Salonen, P. (2011). Socially shared metacognition of dyads of pupils in collaborative mathematical problem-solving processes. *Learning and Instruction, 21*(3), 379–393. https://doi.org/10.1016/j.learninstruc.2010.05.002

Iiskala, T., Volet, S., Lehtinen, E., & Vauras, M. (2015). Socially shared metacognitive regulation in asynchronous CSCL in science: Functions, evolution and participation. *Frontline Learning Research, 3*(1), 78–111. https://doi.org/10.14786/flr.v3i1.159

Kim, B., Park, H., & Baek, Y. (2009). Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning. *Computers & Education, 52*(2), 800–810. https://doi.org/10.1016/j.compedu.2008.12.004

Mayer, R. E. (2014). *Computer games for learning: An evidence-based approach*. MIT Press.

McGonigal, J. (2011). *Reality is broken: Why games make us better and how they can change the world*. The Penguin Press.

Ordin, M., El-Dakhs, D. A. S., Tao, M., Chu, F., & Polyanskaya, L. (2024). Cultural influence on metacognition: Comparison across three societies. *Humanities and Social Sciences Communications, 11*(1), 1492. https://doi.org/10.1057/s41599-024-04013-1

Özçakmak, H., Köroğlu, M., Korkmaz, C., & Bolat, Y. (2021). The effect of metacognitive awareness on academic success. *Academic Exchange Review, 92*(2), 45–56. https://doi.org/10.30918/AERJ.92.21.020

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Pessoa, L. (2008). On the relationship between emotion and cognition. *Nature Reviews Neuroscience, 9*(2), 148–158. https://doi.org/10.1038/nrn2317

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational Psychologist, 50*(4), 258–283. https://doi.org/10.1080/00461520.2015.1122533

Plass, J. L., Mayer, R. E., & Homer, B. D. (Eds.). (2020). *Handbook of game-based learning*. The MIT Press.

Raees Dehghan, A. (2024). *The effectiveness of elementary school games on students' metacognitive skills of the second year of elementary school in the 16th district of Tehran* [Master's thesis, Farhangian University]. Ganj IranDoc. https://ganj.irandoc.ac.ir/#/articles/ff3a5ee93c900d97964bc1cbe76dfb1d/fulltext

Safay Honarvari, H., & Moshkbid Haghighi, M. (2019). Effectiveness of rhythmic games on planning and organizing skills, flexibility, inhibition, and metacognition of pre-school children. *Quarterly Journal of Child Mental Health*, *6*(3), 188–199. http://dx.doi.org/10.29252/jcmh.6.3.17

Shaheen, A., & Fotaris, P. (2024). Embedding reflective game design (RGD) into digital game based learning: Design recommendations and empirical insights. In *Proceedings of the 19th European Conference on Games Based Learning* (pp. 742–750). Academic Conferences International. https://doi.org/10.34190/ecgbl.19.1.2792

Snow, E. L., Jacovina, M. E., Allen, L. K., Dai, J., & McNamara, D. S. (2015). Entropy: A stealth measure of agency in learning environments. In *Proceedings of the 7th International Conference on Educational Data Mining* (pp. 241–244). International Educational Data Mining Society.

Stephanou, G., & Karamountzos, D. (2020). Enhancing students' metacognitive knowledge, metacognitive regulation and performance in physical education via TGFU. *Research in Psychology and Behavioral Sciences, 8*(1), 1–10. https://doi.org/10.12691/rpbs-8-1-1

Suits, B. (1967). What is a game? *Philosophy of Science, 34*(2), 148–156. https://doi.org/10.1086/288138

Takada, S., Marzin, E., & Castro, E. (2023). Promoting learner reflection through a card game: An exploratory study. *JASAL Journal*, *4*(2), 61–86.

Toh, W., & Kirschner, D. (2020). Self-directed learning in video games, affordances and pedagogical implications for teaching and learning. *Computers & Education, 154*, 103912. https://doi.org/10.1016/j.compedu.2020.103912

Udeozor, C., Abegão, F. R., & Glassey, J. (2024). Measuring learning in digital games: Applying a game-based assessment framework. *British Journal of Educational Technology, 55*, 957–991. https://doi.org/10.1111/bjet.13407

van Heereveld, A. (2020). *Motivating students to increase their metacognitive awareness: An exploratory app development study* [Master's thesis, University of Groningen]. University of Groningen Research Portal. https://fse.studenttheses.ub.rug.nl/id/eprint/22562

Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning, 1*(1), 3–14. https://doi.org/10.1007/s11409-006-6893-0

von Gillern, S., & Stufft, C. (2022). Multimodality, learning, and decision-making: Children's metacognitive reflections on their engagement with video games as interactive texts. *Literacy*. https://doi.org/10.1111/lit.12304

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wilson, T., Supian, N., & Cheah, K. S. (2023). Using game-based learning in developing metacognition among ESP students: A case study. *Asian Journal of University Education, 19*(3), 506–517. https://doi.org/10.24191/ajue.v19i3.23495

Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology, 105*(2), 249–265. https://doi.org/10.1037/a0031311

Zirawaga, V. S., Olusanya, A. I., & Maduku, T. (2017). Gaming in Education: Using Games as a Support Tool to Teach History. *Journal of Education and Practice, 8*(15), 55–64.

Appendix

Tables 5–9 illustrate the scoring of studies based on the MMAT tool.

Table 5. The scoring of mixed-methods studies according to the MMAT tool.

Authors & Year	Design	Divergences between qualitative and quantitative results are addressed.	Each component adheres to its respective quality criteria.	Interpretation of combined results is coherent and justified.	Qualitative and quantitative components are effectively integrated.	The rationale for using a mixed methods design is clearly justified.	MMT Score
Chatzipanteli et al. (2015)	Mixed Methods	✕	✓	✓	✓	✓	80%
Braad et al. (2019)	Mixed Methods	✓	✕	✓	✕	✓	60%
Fishovitz et al. (2020)	Mixed Methods	✕	✕	✓	✓	✓	60%
van Heereveld (2020)	Mixed Methods	✕	✓	✓	✓	✕	60%
Takada et al. (2023).	Mixed Methods	✕	✓	✓	✓	✕	60%
Shaheen et al. (2024)	Mixed Methods	?	✕	✓	✓	✓	%70

Table 6. The scoring of Quantitative - Non-randomized studies according to the MMAT tool.

Authors & Year	Design	Interventions are clearly described and consistently applied.	Potential confounders are identified and addressed in design or analysis.	Outcome data are complete for participants.	Measurements are valid, reliable, and appropriate for the study objectives.	Participants are representative of the target population.	MMT Score
Safay Honarvari & Moshkbid Haghighi (2019)	Quantitative - Non-randomized	✓	✕	✓	✓	✕	60%
Stephanou & Karamountzos (2020)	Quantitative - Non-randomized	✓	✓	?	✓	✕	70%
Raees Dehghan (2024)	Quantitative - Non-randomized	✓	✕	✓	✓	✓	80%
Çiftci & Yıldız (2024)	Quantitative - Non-randomized	✓	✕	✓	✓	✓	80%

Table 7. The scoring of Quantitative - Randomized Controlled Trial study according to the MMAT tool

Authors & Year	Design	Outcomes are measured reliably and appropriately	Participants and personnel are blinded to the intervention where possible	Outcome data are complete for all participants	Intervention and control groups are comparable at baseline	Participants are randomly assigned to intervention groups	MMT Score
Beik (2020)	Quantitative - Randomized Controlled Trial	✓	✕	✓	✓	✓	80%

Table 8. The scoring of Quantitative - Descriptive study according to the MMAT tool.

Authors & Year	Design	Statistical analyses are appropriate to answer the research question	Response rate is adequate and accounted for	Measurements are reliable, valid, and appropriate	Sample is representative of the target population	Sampling strategy is relevant to the research question	MMT Score
Snow et al. (2015)	Quantitative - Descriptive	✓	✕	✓	✕	✓	60%

Table 9. The scoring of Qualitative studies according to the MMAT tool.

Authors & Year	Design	There is coherence between data collection, analysis, and interpretation.	Results and interpretations are well substantiated by the data.	Findings are clearly derived from the collected data.	Data collection methods are adequate and suitable for the study objectives.	The study uses an appropriate qualitative approach to address the research question.	MMT Score
Toh & Kirschner (2020)	Qualitative	✓	✓	✓	✓	✓	100%
von Gillern & Stufft (2022)	Qualitative	✓	✓	✓	✓	✓	100%
Wilson et al. (2023)	Qualitative	✓	✓	✓	✓	✓	100%