Maximize Learning and Fun: How to Integrate In-game Learning Supports into Digital Learning Games

Seyedahmad Rahimi, CLASS Lab, College of Lifetime Learning, Georgia Tech, srahimi@gatech.edu
Mahboobeh Mehrvarz, Carnegie Mellon University, mehrvarzmahboobe66@andrew.cmu.edu
Samaneh Abdoli, Farhangian University, samaneh.abdoli67@gmail.com
Salah Esmaeiligoujar, CLASS Lab, University of Florida, s.esmaeiligoujar@ufl.edu
Bruce McLaren, Carnegie Mellon University, bmclaren@andrew.cmu.edu

Abstract: Digital learning games have significant potential to enhance student learning by combining engaging gameplay with academic content. While previous reviews have explored learning supports in games, none have specifically focused on in-game, content-related supports in pre-K-12 settings. This systematic review, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, addresses this gap by analyzing 58 studies to examine the design, delivery, and impact of these supports. Findings reveal diverse outcomes, ranging from cognitive to mixed cognitive and non-cognitive goals. Serious games were the most studied genre, followed by puzzle games. A strong link emerged between the integration level of supports—intrinsic integration—and positive learning outcomes. The delivery method (system-controlled, user-controlled, or mixed) also influenced effectiveness. Most studies (n = 30) used system-controlled delivery, followed by user-controlled (n = 21) and mixed (n = 7). These findings offer guidance for designing learning games that balance engagement and learning.

Introduction

Well-designed digital games on devices such as smartphones or PCs can be effective learning tools (Gee, 2005; Lester et al., 2020; Shute & Ke, 2012). Meta-analyses show that games with clear goals, progressive challenges, and feedback foster learning (Clark et al., 2016; Wouters & van Oostendorp, 2013), often leading to flow (Csikszentmihalyi, 1990). Engagement is consistently linked to learning in games (Rahimi et al., 2022). However, equating all digital games overlooks key differences. Students perceive learning games as distinct from commercial ones, which naturally sustain engagement (Kafai & Burke, 2015). Learning games struggle to balance fun and content, leading to concerns that students may prioritize enjoyment over learning (Ke, 2016). This has driven research on embedding supports to improve both engagement and outcomes (Lester et al., 2020; Rahimi et al., 2021). Embedding supports has proven effective. Wouters and van Oostendorp's (2013) meta-analysis showed that aids like video solutions and hints improved transfer (d = 0.34), while Cai et al. (2022) found a moderate effect (g = 0.43). Yet, distinctions among support types—game-related, content-related, in-game, or external—are often overlooked (Ke, 2016). Well-designed supports enhance competence (Deci & Ryan, 2010), with in-game supports shown to boost content acquisition and engagement (Kuba et al., 2021; Rahimi et al., 2021; Lester et al., 2020). Effectiveness depends on design. Supports aligned with cognitive theories improve engagement and learning (Mayer & Johnson, 2010; Lester et al., 2020). Their timing, delivery (adaptive, optional, mandatory), and integration also matter (Rahimi et al., 2021; Wouters & van Oostendorp, 2013). Intrinsic integration—where supports are seamlessly woven into gameplay—is most effective (Habgood & Ainsworth, 2011; Ke, 2008; Kafai, 1995). For example, pedagogical agents can outperform extrinsic aids like hyperlinks (Schrader & Bastiaens, 2012; Lester et al., 2020).

In-game supports include content-related (domain knowledge), game-related (mechanics/navigation), and self-regulated learning supports (goal setting, monitoring, reflection) (Ke, 2015; Lester et al., 2020; Rahimi et al., 2021). Ke (2015) further categorizes content-related supports as cues/feedback, explicit instruction, and processing tools. This review focuses on in-game, content-related supports.

The current systematic review

While research on learning games is growing, no systematic review focuses solely on in-game, content-related learning supports in pre-K-12 education. This review offers insights for learning game designers, researchers, and learning scientists. By creating games as engaging as commercial, non-educational ones, we aim to foster deeper learning and real-world knowledge transfer, avoiding the "chocolate-covered broccoli" effect (Burkman, 1999), where educational games lack appeal. This review addresses the following research questions: *RQ 1) What are the trends in learning in studies examining the effects of in-game, content-related learning supports in learning games? RQ 2) What are the effects of these learning supports on student learning outcomes? RQ 3) How should these learning supports be designed to maximize learning outcomes?*

Method

This review follows the PRISMA guidelines (Moher et al., 2009), providing a standardized framework for systematic reviews. We used a multi-phase approach to identify and analyze studies on learning supports in digital game-based learning, including title/abstract screening, full-text review, and quality assessment. To ensure comprehensive coverage, we applied snowballing to capture additional literature. Finally, we extracted data from the included studies to address our research questions.

Search strategy and inclusion and exclusion criteria

We searched Scopus, Web of Science, ERIC, PsycINFO, Science Direct, and Google Scholar for their broad coverage of relevant topics. The strategy was refined through exploratory searches, using keywords on learning supports, digital game-based learning, and pre-K–12 education. Boolean operators ("AND," "OR") combined synonyms and related terms, with adjustments for each database's functions [e.g., ("Game-based learning" OR "serious games" OR "educational games" OR "simulation games" OR "digital games" OR "video games" OR "instructional games") AND ("learning supports" OR "instructional supports" OR "cognitive supports" OR "learning content" OR "learning materials" OR "help" OR "assistance" OR "guidance") AND ("K-12" OR "elementary" OR "primary" OR "secondary" OR "pre K-12")]. Studies were then reviewed in two phases—primary and secondary—using the inclusion and exclusion criteria detailed in Table 1.

Table 1
Inclusion and Exclusion Criteria

Criteria		Inclusion	Exclusion
Primary (Title & Abstract)	Date	No restriction	-
	Language	English	Non-English
	Relevance (1)	Mention of "game" in (Title, Abstract, Keywords)	If no mention of "game" in the title, abstract, or keywords
	Manuscript Type	Empirical (Quantitative, Qualitative, & Mixed)	Literature Reviews, Meta-Analyses, Reports, Theoretical Articles, and Books.
	Target Audience & Educational Level	Mainstream students; pre-K12	Students with disability; beyond pre-K12
Secondary (Full-Text)	Relevance (2)	Learning Supports designed and discussed; Digital games; All Genres	Non-digital games; No in-game learning supports

Screening process

The screening process followed a structured, multi-phase approach. Duplicate records were removed in Zotero (Roy Rosenzweig Center for History and New Media, n.d.), excluding 545 papers. Three researchers (co-authors) reviewed the inclusion and exclusion criteria (Table 1), independently screened ~100 titles/abstracts, and met to resolve discrepancies before each proceeded to screen one-third of the remaining studies. Papers passing this phase underwent full-text review in Covidence (Covidence, n.d.), with two researchers independently reviewing each and weekly meetings to resolve conflicts. Snowballing—both backward (reference lists) and forward (citation tracking)—identified seven additional studies, bringing the total to 58. A final quality assessment confirmed all met methodological standards.

Assessment of study quality

We assessed study quality using the Critical Appraisal Skills Programme (CASP) checklist (Singh, 2013), focusing on research aims, methodology, and data processes. Of the 58 studies, 44 were quantitative and 14 mixed methods. Mixed methods were further evaluated using Pluye et al. (2009), which added criteria on justification, data integration, and reliability, in addition to recruitment, sampling, validity, and generalizability. Quantitative studies were assessed with a modified CASP emphasizing objectives, methodology, recruitment, sampling, validity, confounding controls, and clarity of results. Each criterion was scored 0 (not met) or 1 (met), with thresholds from Pluye et al. (2009): high quality (>70%), medium (40–70%), or low (<40%). A second researcher independently reviewed all studies, and ratings were averaged. All 58 studies met minimum quality standards, with none rated low, and were therefore included. From each study, we extracted data on outcome variables, subject matter, audience, sample size, game genre, type and delivery of supports, and their integration into games.

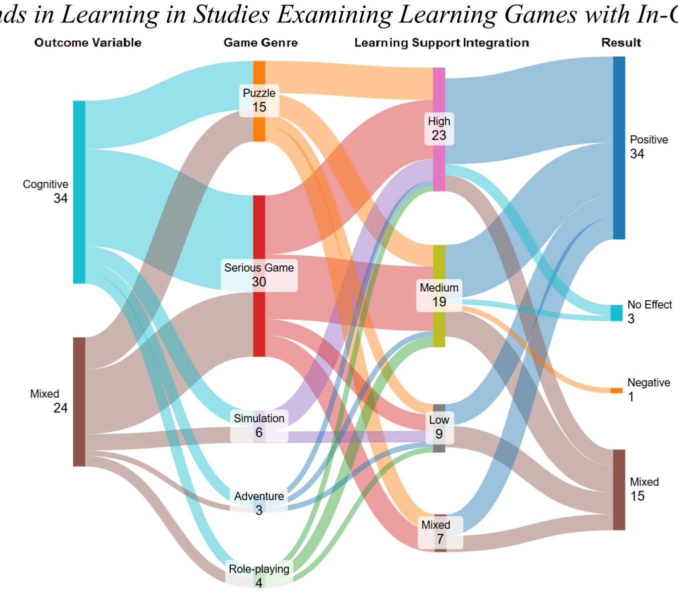
Results

RQ 1: What are the trends in learning in studies examining the effects of in-game, content-related learning supports in learning games?

The included studies comprised journal papers (*n* = 47; 83.93%), proceedings (*n* = 5; 8.93%), dissertations (*n* = 3; 7.14%), and white papers (*n* = 2; 3.57%). Figure 1 illustrates the relationships among four key variables. The first layer categorizes outcome variables, distinguishing between cognitive outcomes (*n* = 34) and mixed outcomes (*n* = 24, combining cognitive, meta-cognitive, affective, or behavioral). The second layer highlights game genres, including serious games (*n* = 30), puzzle games (*n* = 15), simulations (*n* = 6), adventures (*n* = 3), and role-playing games (*n* = 4). Serious games were designed for training or learning, combining education with engaging gameplay, such as *Foldit* (Winget, 2011). Puzzle games emphasized logical thinking and problem-solving, as in *Tetris* (Entertainment Software Association, 2019). Simulation games mimicked real-world activities like managing or flying, exemplified by *The Sims* (Entertainment Software Association, 2019). Adventure games centered on storytelling and exploration, requiring interaction with environments, such as in *The Legend of Zelda: Breath of the Wild* (Clarke et al., 2017). Role-playing games focused on character development and narrative, as in *The Witcher 3: Wild Hunt* (Gray, 2017).

Figure 1

Trends in Learning in Studies Examining Learning Games with In-Game Learning Supports



The third layer reflects the integration of learning supports, which ranged from low, where supports were weakly related to gameplay and often disrupted flow (e.g., pausing to watch a video with a different style), to medium, where interruptions remained but the supports matched the game's look and feel, to high, also known as intrinsic integration (Habgood & Ainsworth, 2011; Kafai, 1995), where supports were seamlessly embedded with minimal disruption. Some studies employed mixed integration strategies, such as combining videos with intrinsically embedded supports. Within this review, studies were classified as high (*n* = 23), medium (*n* = 19), low (*n* = 9), or mixed (*n* = 7). Finally, the fourth layer captures study results, with 34 reporting positive effects, 3 showing no effect, 15 yielding mixed findings, and 1 reporting a negative effect. The visualization highlights strong connections between serious games and positive outcomes, particularly when cognitive outcomes were examined and supports were highly integrated. Puzzle games also showed notable associations with positive results, though findings varied depending on support integration, while lower or mixed levels of integration were more often associated with mixed outcomes.

RQ 2: What are the effects of these learning supports on student learning outcomes?

As mentioned above, 34 studies reported positive results, 1 study indicated a negative effect, 15 studies showed mixed results, and 3 studies found no significant effects regarding the inclusion of learning supports in learning games. To draw a more definitive conclusion from these findings, a meta-analysis is necessary. However, the results suggest that the majority of studies uncovered positive effects when learning supports were incorporated into the games. Further investigation is needed to understand why these outcomes occurred. Factors such as the duration of the interventions, the design and integration of the learning supports, sample size, and other study details could provide valuable insights. Next, we focus on RQ3, which relates to the design of the learning supports.

RQ 3: How should learning supports be designed to maximize learning outcomes?

The first design aspect concerns the level of integration. As shown in Figure 1, supports were categorized as Low (*n* = 9), Medium (*n* = 19), High (*n* = 23), or Mixed (*n* = 7) (see RQ1 for definitions). Most studies employed medium or high integration, and these were generally associated with positive learning outcomes. This finding suggests that researchers sought to embed supports in ways that were minimally disruptive, with high integration meaning supports were seamlessly woven into gameplay. The second aspect relates to the delivery method. Of the 58 studies, 30 used system-controlled delivery, 21 user-controlled, and 7 a Mixed approach. System-controlled supports relied on mechanisms such as adaptive algorithms informed by in-game analytics or assessments, delivering "just-in-time" assistance (e.g., *Physics Playground*, *Crystal Island*). User-controlled supports allowed learners to seek help voluntarily, typically via a help center or button. Mixed approaches combined both, offering learners flexibility while ensuring timely interventions.

Discussion & Conclusion

The inclusion of academic content and learning supports in games remains a persistent challenge (Wouters et al., 2013; Ke, 2016). While prior reviews examined supports broadly, none have focused specifically on in-game, content-related supports. This review fills that gap by synthesizing research on digital game-based learning. Findings show that games target diverse outcomes, from cognitive domains (e.g., math, science, physics) to combined cognitive and non-cognitive outcomes (e.g., attitudes, enjoyment, motivation), underscoring their educational potential. Serious games were the most common genre, reflecting their design to embed academic content, followed by puzzle games, which align well with problem-solving mechanics. A central finding is the link between support integration and learning impact. Consistent with prior work (Kafai, 1995; Kafai & Burke, 2015; Ke, 2016), studies employing high (intrinsic) or mixed integration reported the most positive outcomes, suggesting that supports are most effective when seamlessly embedded in gameplay. Adaptive or evidence-based delivery systems further enhance effectiveness, though many studies still relied on learner-initiated supports, which risk being ignored. Incentive systems may help (Rahimi et al., 2021), but supports must be carefully designed to sustain attention. In sum, digital learning games can be highly effective when supports are integrated thoughtfully. To enhance learning without reducing engagement, supports should maintain gameplay enjoyment while reinforcing content. Games that achieve this balance can promote sustained engagement and deeper learning.

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