Gamified scaffolding in formal education: A scoping review

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Abstract

Prior reviews that investigated scaffolding in games concluded that combining game-based learning with scaffolding can support learning. Less emphasis has been placed on determining which motivational affordances would specifically contribute to and support scaffolding in a gamified learning environment. This scoping review aims to determine which motivational affordances have been utilised to scaffold learning in a digital learning environment. Results show that effective implementation of all elements of scaffolding in gamified digital environments remains challenging, specifically the fading of support. Results also show that feedback as motivational affordance is utilised more often compared to the more commonly implemented affordances such as points, badges and leaderboards. More careful consideration in the design of the gamified scaffold to calibrate and fade the support is required and more longitudinal empirical studies with rigorous methodologies and larger sample sizes would offer greater insight into the intricate interweaving of gamification and scaffolding.

Keywords: Engagement, Game-based learning, Gamification, Motivation, Performance.

1. Introduction

When teaching-learning activities occur in constructivist classroom environments, educators act as guides who diagnose the comprehension degree of each learner, calibrate the required guidance based on such diagnoses, and then progressively decrease the support level until mastery is achieved — a process referred to as *scaffolding* (Azevedo & Hadwin, 2005; Stone, 1998). On top of these three deliberate actions, continuous feedback and gradual increase in the tasks complexity are crucial components for effective scaffolding (Reiser, 2004; Stone, 1998). While adjusting these aspects in a classroom environment is relatively natural, it becomes more challenging in an online, asynchronous context, as it is difficult to anticipate the time or type of support needed, how this support should be presented and whether it should be requested by or forced upon the learner (Reiser, 2004).

Scaffolding in online environments includes adding supplementary resources, questioning and feedback (Doo et al., 2020). Furthermore, another emerging method is *gamification*, which creates a more game-like learning environment. Gamification provides, among other components, the opportunity for continuous feedback (e.g., points, badges) and the progressive increase in difficulty (e.g., levels, boss fights), whilst affording skill development and motivation benefits (Hamari, 2019). Although using scaffolding in digital game-based learning (GBL) has already shown positive results (Cai et al., 2022), literature to support the understanding of how scaffolding and gamification overlap and complement one another is still sparse. Thus, this gap prevents further research and developments on how they can be integrated into teaching-learning processes, what outcomes could be expected, and whether they are consistent.

This study consolidates the state-of-the-art on the intersection between gamification and scaffolding in formal teaching-learning processes through a scoping review. This review particularly focuses on individual aspects of scaffolding and gamification addressed in the literature, how they are combined, and which outcomes have been achieved. Furthermore, we discuss current gaps and future agenda towards promoting more and improved means to gamify instructional scaffolding.

2. Background

2.1. Scaffolding

Scaffolding is an instructional process where an expert assists learners to either solve a problem, carry out a task or achieve a goal currently beyond their unassisted capabilities (Cai et al., 2022; Stone, 1998; Wood et al., 1976). In a formal education environment, scaffolding occurs naturally and dynamically when

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an educator, as the expert, diagnoses learners' comprehension and calibrates the assistance given. This assistance is gradually reduced while the learners' responsibility increases toward mastering the necessary skills to perform the task independently (Puntambekar & Hubscher, 2005; Van De Pol et al., 2010). Scaffolding coincides with Vygotskij (1981) Zone of Proximal Development (ZPD), as the support is aimed to lie within the learner's actual level of development to complete the task independently and their potential level to complete the task with support.

Investigating the impact of scaffolding on learning tends to focus on formal settings using online or computerised learning environments (Belland et al., 2017; Doo et al., 2020). Scaffolding is more widely applied in second language learning and literature studies (Doo et al., 2020; Van De Pol et al., 2010), but also in STEM (Science, Technology, Engineering and Mathematics) (Belland et al., 2017; Reiser, 2004). Scaffolding outcomes mainly focus on cognition, as improving subject-matter learning and behaviour result in better engagement, since learners function within their ZPD (Van De Pol et al., 2010).

Different technologies can be used to scaffold, but a careful decision is required as to what and how it should be implemented. Reiser (2004) suggests that scaffolding should either support learners by breaking down activities into smaller parts and gradually building towards a full understanding or, alternatively, challenge learners by problematising important content. Scaffolding mediated by technology can also be designed for specific purposes, such as introducing concepts (i.e., conceptual scaffolding), helping to understand different resources (i.e., procedural scaffolding) or methods to solve a problem (i.e., strategic scaffolding) or motivating task completion (i.e., motivational scaffolding), and finally reflecting on learners' own learning (i.e., meta-cognitive scaffolding) (Belland et al., 2017; Hannafin et al., 2013). Some examples of these types of scaffolding include offering additional information or graphical organisers, gradually increasing the difficulty levels or offering hints to solve the problems and giving continuous feedback by using questioning techniques (Melero et al., 2011; Reiser, 2004).

It is more challenging to dynamically adjust the support level required by each learner in an online learning environment, regardless of the scaffolding purpose. This lead to more static scaffolds (e.g., preempting where learners may experience difficulties or require more information and extending this support to all learners (Belland et al., 2017)), but adding game design elements could offer an alternative approach. However, the two major challenges faced by educators when implementing online scaffolding (i.e., determining how to successfully fade the support dynamically and whether each learner should decide when additional support is needed) still remain (Belland et al., 2017).

2.2. Gamification

Originally, gamification was strictly defined as the use of game design elements in non-game contexts (Deterding et al., 2011). More recently, Hamari (2019) contended gamification as an emergent concept that comprehends any technological, economic, cultural and societal development that leads to a more gameful reality. Thus, this new perspective implies that related areas that focus on fully-fledged games in education (e.g., serious games and GBL) are also part of gamification (Hamari, 2019; Krath et al., 2021). In educational domains, gamification is the intentional addition of motivational affordances to any learning activity towards simulating game-like positive experiences (Majuri et al., 2018). Motivational affordances are game elements implemented to achieve specific psychological outcomes, such as intrinsic motivation, that potentially lead to behavioural changes (Koivisto & Hamari, 2019; Majuri et al., 2018).

Especially due to its intrinsic motivation benefits, gamification is inviting to educators and researchers, as it supports three innate needs: competence, autonomy, and relatedness (Koivisto & Hamari, 2019; Ryan & Deci, 2000), which are the bases for the Self-Determination Theory (SDT) (Deci & Ryan, 2012). Gamification can promote a sense of competence through achievement-based affordances (e.g., points, leaderboards and levels), autonomy through immersion-based affordances (e.g., narrative, exploration, customisation), and relatedness through social-based affordances (e.g., multi-player options, competition and teams) (Barata et al., 2017; Majuri et al., 2018; Sailer et al., 2013; Yee, 2006). While being heavily reliant on SDT as its most frequent theory (Krath et al., 2021; Seaborn & Fels, 2015), gamification is also often linked to other psychological theories, such as flow (a holistic sensation that people feel when they engage fully in an action (Csikszentmihalyi, 2000)), goal-setting (the definition of clear and challenging objectives which people accept and are committed to achieving (Locke, 1968)) and cognitive load (the avoidance of an overloading amount of information at one time (Sweller, 1988)). Beyond psychological outcomes, behavioural outcomes of gamification include higher completion rates (Koivisto & Hamari, 2019) and improved academic performance

(Krath et al., 2021). Yet, mixed results from gamified educational studies suggest that a combination of psychological and behavioural theories is required to improve learning outcomes, as gamification can e.g., improve learning but cause anxiety (Bai et al., 2020).

2.3. Gamified scaffolding

The combination of scaffolding and gamification (i.e., gamified scaffolding) in pedagogical activities is instrumental to ensure learners' productive and enjoyable experience by providing support for those experiencing difficulties, better connecting the curriculum and assisting in problem-solving strategies (Bado, 2022). However, there is still little understanding of factors that are highly relevant and may impact current outcomes, such as intrinsic motivation, flow, goal orientation and cognitive load, as well as whether these outcomes are still applicable when the focus is more specifically on gamification compared to GBL. Prior studies have analysed scaffolding effectiveness in GBL environments, but not in gamification, and these studies' results suggest that combining scaffolding and games can be effective in improving learning outcomes, especially in performance and knowledge acquisition, retention and transfer (Cai et al., 2022).

Another review on GBL (Melero et al., 2011) identified that game worlds, simulations and adventure games are the preferred genres applied with scaffolding, but such games are developed by skilled developers and not by educators. Thus, it is further unclear to what extent educators would be able to develop their own GBL approaches, taking into account the educational needs of their situation, or even how they can design scaffolding approaches properly integrated into games.

Though these studies offer insights into the combination of scaffolding and GBL, there is still a dearth of knowledge on the intersection between scaffolding and gamification, as a broader term. This gap prevents further understanding of which scaffolding and gamification aspects are being considered and whether they address existing challenges (e.g., how to fade the scaffold successfully or to combine psychological and behavioural outcomes). Thus, our study contributes to the literature by describing the state-of-the-art of gamified scaffolding in formal education through a scoping review and suggesting a future agenda, particularly answering: *RQ1)* What aspects of scaffolding are considered?, *RQ2)* What aspects of gamification are considered?, *RQ3)* How they are being combined and by whom?, and *RQ4)* What outcomes appear from this combination?

3. Methodology

A literature review is a systematic, explicit, comprehensive and reproducible study that effectively identifies, evaluates and synthesises the existing works in a specific field (Fink, 2019). Our scoping literature review synthesises the state-of-the-art of gamified scaffolding in formal educational settings following the Preferred-Reporting of Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018), as described throughout this section.

3.1. Search engines and keywords

Driven by other systematic studies on scaffolding or gamification (Belland et al., 2017; Cai et al., 2022; Doo et al., 2020; Krath et al., 2021; Majuri et al., 2018), we identified six predominant scientific databases that were used in this study: ACM Digital Library, IEEE Xplore, Scopus, Web of Science, ProQuest and EBSCOhost.

A popular method for defining search terms is PICOC, which identifies Population, Intervention, Comparison, Outcomes, and Context (Petticrew & Roberts, 2006). In this case, our *population* is any study using scaffolding to support learners; *intervention* is any teaching method applying gamification in learning environments; no *comparison* was made, as this study aims to describe the state-of-the-art; *outcomes* are any effects that gamified scaffolding had on learners; and *context* comprises formal teaching, tutoring or learning. Based on this PICOC, three major sets of keywords were defined, being: *scaffolding* covering terms as scaffold and scaffolded; *gamification* covering terms as gameful, playful and gamified; and *formal education* covering terms as learn, teach, instruction and tutor. Thus, the search string is *scaffold* AND (game* OR playful OR gami*) AND (learn* OR teach* OR instruction* OR education* OR tutor*)* - where * is a wildcard. This string was searched within the title, abstract and keyword of studies published up to September 2022. In an effort to ensure a comprehensive search on gamification, playful was included in the search string, which implies fun-filled activities, but does not include play, which is a complex construct. Including play would have resulted in an unmanageable number of studies to be considered and not meeting the objective of this review. None of the studies that met all the inclusion criteria made any reference to playful.

3.2. Selection criteria

The initial 2458 hits from the search, after removing 1170 duplicates, allowed the abstract and

full-text screening of 1288 studies, according to the following selection criteria: *1)* Written in English; *2)* Published in peer-reviewed academic journals, conference proceedings, or book chapters; *3)* Full-text available; *4)* Applied in a formal education setting; *5)* Addressing both scaffolding and gamification explicitly in the learning experience; and *6)* Reported an empirical examination of the gamified scaffolding learning experience. This screening of eligible studies is detailed in the PRISMA Flow Diagram (Figure 1). Ultimately, 15 studies met the selection criteria (Abdool et al., 2017; Anderson et al., 2015; Butler & Bodnar, 2017; Foster et al., 2012; Hou et al., 2023; B. Huang et al., 2018; C.-Y. Huang et al., 2019; Jones & Sturrock, 2022; Katz et al., 2014; Li et al., 2019; Puig et al., 2022; Schaper et al., 2021; Tan, 2018; Tsai, 2018; Von Kotzebue et al., 2022), being listed in Included studies and cited from now on as [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15] respectively. No additional studies were identified through backward tracking.

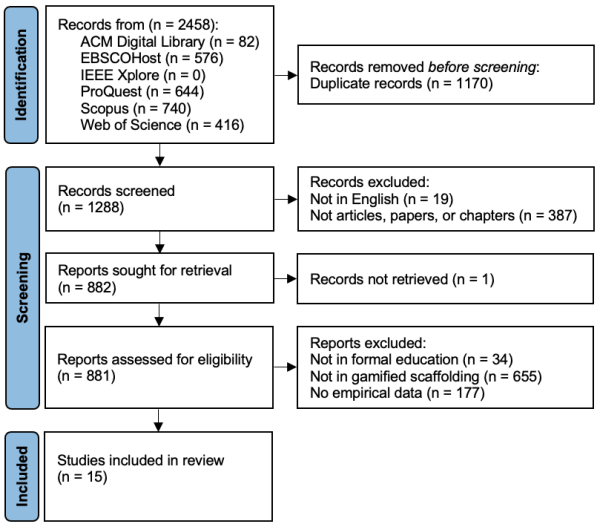

Figure 1. PRISMA Flow Diagram

3.3. Data extraction

We extracted information on education levels and disciplines, scaffolding methods, activities being scaffolded, scaffold purpose (i.e., conceptual, procedural, strategic, motivational or meta-cognitive) and type (i.e., static or dynamic) to answer which scaffolding aspects were considered (RQ1). Information on whether gamification was implemented as a fully-fledged game or through motivational affordances, as well as which motivational affordances were incorporated, supported the understanding of the gamification aspects considered (RQ2). The combination of scaffolding and gamification (RQ3) was coded based on its focus (i.e., mainly on scaffolding, on gamification, or equally distributed), on where gamified scaffolding happened (i.e., in-class or online activities), whether they were embedded within each other or separately, and which theories and frameworks supported its implementation. The outcomes (RQ4) were categorised either as psychological or behavioural. Psychological outcomes included motivation, engagement, and interest, whereas behavioural outcomes included academic performance, completion rates and participation. These outcomes were either positive, negative, or mixed. Moreover, we extracted their methodologies (i.e., quantitative, qualitative or mixed) and the methods used to collect the data, sample sizes and experimental designs, as they highly influence the reported outcomes.

4. Results

4.1. Scaffolding aspects (RQ1)

Gamified scaffolding was predominantly applied in higher education (n = 8, [1, 2, 3, 4, 6, 8, 12, 13]), whilst the remaining studies are spread over elementary [10], middle [9, 11, 14, 15] and high school level [5, 7]. Furthermore, most studies (n = 10) applied scaffolding in STEM disciplines, such as science [5, 7, 14, 15], computer programming and data science [1, 2, 6], engineering [3, 4], and mathematics [11]. Despite not being predominant, gamified scaffolding was also applied in diverse contents, including forensic [8], cognitive training [9], history [10], second language [12], and women in cinema [14].

The scaffolding methods adopted included numerous methods, especially related to giving feedback and breaking the content down into smaller pieces to allow for a gradual increase in difficulty levels, as shown in Table 1. This result supports that scaffolding aimed to support the learner from novice to master, whilst offering feedback during this process. Scaffolded activities either required learners to solve authentic problems [2, 3, 5, 7, 10, 15], experiment with different scenarios for more inquiry-based evaluations [8, 11, 14], create a visualisation or model of concepts and relationships [1, 12], or evaluate the design of products [4]. Yet, some studies did not explain the activities being scaffolded in detail [6, 9, 13].

Regarding the scaffolding purpose, all studies were motivational, as their aim was to positively affect psychological and behavioural changes by providing game-like experiences. Some studies also tackled conceptual scaffolding [4, 5, 7, 11]

Table 1. Most used scaffolding methods

Scaffolding method	Total	Studies
Give feedback	13	All except [4, 9]
Break content down	9	[2, 3, 8, 9, 11, 12, 13, 14, 15]
Supply extra materials	4	[1, 4, 5, 7]
Direct questioning	1	[10]

by highlighting important items to learners when they investigated a problem and by breaking down bigger concepts into smaller pieces. Other studies addressed strategic scaffolding [1, 2, 14] by guiding learners through specific thought processes that offered different alternatives to solve a problem, and procedural scaffolding [1, 10] by assisting learners to effectively use their available resources in solving a problem.

Static scaffolding was offered in most studies, as no addition or fading of support happened during the learning activity [6, 8, 9, 11, 12, 13, 14, 15], while only [4] provided dynamic scaffolding where educators provided support based on learners' needs. In detail, static scaffolding was majorly implemented upfront and in digital environments with no further intervention or feedback, even when educators were present during the activity. Meanwhile, dynamic scaffolding was provided in classroom settings with an educator present to provide support and correct misunderstandings. Yet, six studies [1, 2, 3, 5, 7, 10] had a combination of both static and dynamic scaffolding, in which extra support was provided by the tool as well as by educators, peers or teaching assistants. In the classroom environment, the educator provided feedback at the end [2, 3, 10] and peers provided the scaffolding during the activity [5, 7], whereas in [1], the teaching assistant provided guidance and feedback on submitted reports after the activities were submitted in the digital environment. While learners had no choice but to accept the additional support in most cases, three studies [2, 3, 15] allowed learners to self-select support by clicking on the help function, and two [9, 10] incorporated performance-adapted scaffolding, whereas the software adjusted the difficulty level based on learners' progress.

4.2. Gamification aspects (RQ2)

Within the 15 studies, gamification mostly appeared as a fully-fledged game (n = 9, [2, 5, 7, 9, 11, 12, 13, 14, 15]), whilst the remaining incorporated motivational affordances in an existing learning environment [1, 3, 4, 6, 8, 10]. This supports Hamari (2019)'s broader understanding of gamification as an umbrella concept that comprises serious games and GBL. Some examples include board games using augmented reality [5, 7], digital detective games [13, 14], and escape rooms [10, 15]. Regardless of being a fully-fledged game or not, the most implemented motivational affordance was feedback (86%), which comprises either verbal comments by educators or peers [3, 5, 7, 10], written explanations on incorrect answers [1, 8] and visual system reports in terms of achievements and overall progress [2, 5, 6, 11, 12, 13, 14, 15]. Other popular motivational affordances included points, challenges, and narratives, as depicted in Table 2. Specifically, narratives provided context to gamification and created tension, despite criticism that they could be either too superficial or disconnected from content [13] or not contribute to the learning experience [9].

Table 2. Most used motivational affordances

Affordance	Total	Studies
Feedback	13	All except [4, 9]
Points	9	[1, 2, 3, 5, 7, 8, 9, 11, 14]
Challenges	8	[2, 3, 6, 8, 10, 11, 13, 15]
Narrative	7	[5, 9, 11, 12, 13, 14, 15]
Badges	6	[2, 3, 4, 6, 11, 12]
Levels	6	[1, 3, 8, 9, 11, 14]
Cooperation	5	[1, 4, 5, 7, 10]
Leaderboards	3	[6, 10, 11]
Avatars	3	[3, 11, 13]
Progress bars	3	[2, 11, 12]
Surprises	2	[9, 11]
Time pressure	2	[11, 14]

Gamification mainly focused on promoting competence through achievement-based affordances (i.e., feedback, points, challenges, badges, levels, leaderboards, progress bars, and time pressure), with some sense of autonomy through immersion-based affordances (i.e., narrative, avatars, and surprises) (Yee, 2006). Social-based affordances were limited to cooperation, being implemented by only five studies.

4.3. Gamified scaffolding (RQ3)

In combining scaffold and gamification, a perceived unbalance emerged either favouring gamification [1, 3, 4, 6, 7, 9, 10, 12, 13, 14, 15] or scaffolding [8], while only a few studies placed equal emphasis on both [2, 5, 11] in their writing. Overall, these balanced studies used feedback, narrative, badges and levels to scaffold the learning content. Tasks were broken down into smaller parts to create levels and, once a level is completed, a badge is awarded to unlock the next level [2, 11]. The narrative gave context and supported learners in the next step [5, 11], whilst feedback was generated by the system [2, 5, 11] or offered by peers [5].

Gamified scaffolded activities are also mostly implemented as an in-class activity where educators were on site [4, 5, 7, 9, 10, 11, 12, 14, 15], followed by online activities wherein scaffolding was automatically incorporated [1, 2, 3, 6, 8, 13]. These settings can also explain the unbalanced focus on gamification, given those offering the scaffold were present and additional support happened in real-time. Almost all studies implemented scaffolding and gamification together as one (i.e., one within/intertwined with the other), with [15] being the only exception by providing optional support to learners that could not solve a puzzle, which is regarded as a separate activity. Of the studies in static scaffolding, six had fully-fledged games [9, 11, 12, 13, 14, 15] and two implemented motivational affordances [6, 8] (which was also used in dynamic scaffolding [4]), whereas combining static and dynamic was equally used with games [2, 5, 7] and affordances [1, 3, 10].

Despite most studies implementing interventions and reporting preliminary results, gamified scaffolding drew little attention to design considerations of this combination, with only two studies applying a specific framework to support such implementation, being: their own framework [6] and the LEGA framework [14]. Studies were also not consistently grounded in educational or psychological theories, as only a few referred to theories commonly applied in gamification and scaffolding: SDT [6, 12] and cognitive load theory [15], while no study referred to the ZPD.

4.4. Outcomes (RQ4)

All studies analysed at least one psychological outcome of gamified scaffolding, especially motivation (n = 9), with an overall predominance of positive results, as Table 3 shows. Likewise, all studies but [12] analysed at least one behavioural outcome, reporting majorly positive effects on performance, participation, and interest. Still, [9, 12] reported no effects on learners' intrinsic motivation or performance when changing themes or adding surprises, despite the positive results on extrinsic motivation. Narratives and challenges also did not affect motivation or immersion, but improved learners' performance and interest in [15]. On top of that, there were some negative reports about the interventions related to limited avatar customisation [13], delay in feedback time [2], and the perceived usefulness as learners did not understand the link between quests and the content [3] or focused more on collecting points and cheating the system [4]. Some learners uncomfortable with public speaking felt intimidated and commented negatively on the experience [8].

Table 3. Outcomes of gamified scaffolding

Psychological outcome		**Negat.**	**Neutr.**	**Posit.**
Quant.	Motivation		[9, 12, 15]	[9, 11, 12, 14]
	Flow			[7, 10]
	Immersion		[15]	[7, 10]
	Tech. acceptance			[7, 10]
Qual.	Engagement	[4]		[4]
Mixed	Motivation			[1, 3, 6, 13]
	Engagement	[8]		[8]
	Enjoyment	[2]		[2]
	Anxiety			[5]
Behavioural outcome		**Negat.**	**Neutr.**	**Posit.**
Quant.	Performance		[9]	[7, 9, 10, 11, 14, 15]
	Interest			[14, 15]
Qual.	Performance	[4]		[4]
Mixed	Participation	[2, 3, 13]		[2, 3]
	Performance	[8]		[5, 8]
	Interest			[1, 6]

In general, there is a balance between studies that applied a quantitative approach to those that employed a mixed-methods, while only [4] applied a purely qualitative approach by analysing teaching assistants' observations. Quantitative methods collected learners' usage through data logs and performance through pre- and post-tests, while qualitative ones appeared as focus groups, interviews and surveys to collect feedback. Despite surveys being used by almost all studies, only a few scholars employed validated survey instruments, such as the IMI [13], MUSIC [3], Flow and TAM [7, 10], and User experience surveys [12].

From quantitative and mixed-methods approaches, nine studies had a single-group design (i.e., all learners were using the gamified scaffolding intervention) [1, 2, 3, 5, 7, 8, 10, 13, 14], while four had a two-group experimental design (i.e., learners were divided into two groups, of which one used the gamified scaffolding intervention and the other were the control group without the intervention) [6, 11, 12, 15] and one study had a seven-group design (i.e., learners were divided into seven groups, of which one motivational affordance was removed for six groups and one group had all seven motivational affordances included) [9]. Sample sizes remain small, with nine studies with a sample size of less than 50 [1, 2, 3, 5, 7, 8, 10, 12, 13] and only two with a sample greater than 100 [4, 9].

5. Discussion

As previously stated, most studies on gamified scaffolding were in higher education, with a particular focus on STEM disciplines, which shows a difference from traditional scaffolding that tends to focus on languages and literature (Doo et al., 2020; Van De Pol et al., 2010). Most studies also provided static scaffolding, especially in digital environments, and only two studies incorporated software automation in the adaptation of the content difficulty level based on learners' performance. Meanwhile, as anticipated given their game-like nature, all studies implemented motivational scaffolding, but only four used conceptual scaffolding, three provided strategic scaffolding, and two of them assisted with procedural scaffolding. It was interesting to note that none of the studies focused on meta-cognitive scaffolding to assist learners in reflecting and monitoring their learning process, which contrasts with the findings of Doo et al. (2020), who found that most scaffolding aimed to be meta-cognitive in their nature. Furthermore, the scaffolding aspects were insufficiently described and often rather inferred with only four studies addressing this teaching strategy in detail in their writing [2, 5, 8, 11]. For instance, [2] purposefully divided the larger tasks into smaller ones and the completion of the smaller parts built up to mastering the larger challenge in a full-fledged game for undergraduate data science learners. Similarly, [8] applied scaffolding with motivational affordances for undergraduate forensic sciences learners when they released information and provided continuous feedback in a flipped classroom. More integrated with the gamification aspects, [5] developed a scaffolding-based game editor for high school chemistry learners that allows for the creation of augmented reality game cards. Finally, [11] designed a geometry game for middle school maths learners that scaffold learners' understanding between 2D and 3D shapes.

Regarding gamification, studies were almost equally implementing specific motivational affordances and fully-fledged games, highlighting that gamification is becoming increasingly an umbrella term that goes beyond simply using game elements. Whether being a fully-fledged game or not, the most common motivational affordances for gamified scaffolding were feedback, points, challenges, and narratives. This result contrasts with studies on gamified learning since points, challenges, badges, and leaderboards are the most common affordances (Majuri et al., 2018). Yet, 13 out of the 15 included studies used at least one of the three most explored affordances associated with gamification (i.e., points, badges, and leaderboards), indicating that these affordances are still popular. Nevertheless, it is interesting that leaderboards did not feature highly amongst the studies, as gamified scaffolding aimed not only at motivating the learner but more towards supporting their learning path. More specifically, studies using motivational affordances mostly implemented points and levels in more out-of-class activities that focused on applying learners' knowledge, providing a more dynamic scaffolding process. In contrast, studies implementing scaffolding in fully-fledged games mostly divided their instructional content into levels and aimed to motivate the learners in a static manner. These fully-fledged games commonly applied feedback and narrative while assessing learners' understanding of concepts. Furthermore, most studies implemented these games in a classroom setting in which the educator was present during the learning activity but relied on the game to provide scaffolding instead of offering extra support from educators in real time.

While most studies focused more heavily on gamification aspects, studies that implemented gamified scaffolding in a more balanced way centred the gamification design in providing feedback to the learners, which distinguishes the core of gamified scaffolding from other gamification uses. Other than feedback, motivational affordances that could be easily associated with scaffolding by gradually increasing complexity level, such as points, challenges, narrative, badges and levels, were also frequently included. This is somewhat in line with prior results on gamification, so there is no clear divergence from gamified scaffolding – except for narrative, which appeared more frequently in scaffolding than in gamification as a whole. Yet, using frameworks to support the design of gamified scaffolding is rather rare, and educational and psychological theories used to provide common ground were not consistent.

Studies mainly analysed the influence of gamified scaffolding in motivation and academic performance (9 studies each), followed by engagement, interest and participation (4 studies each), which implies that both psychological and behavioural effects are being measured. The results were mainly positive, especially towards improving learners' performance and increasing motivation, engagement and participation, but studies also reported negative effects related to feedback time, avatar customisation, the usefulness of the intervention and cheating attempts. Common limitations noted from studies were the small sample sizes, the once-off occurrence of the intervention and the lack of longitudinal information and finally, the fact that most studies only had one group and not an experimental methodology making generalisation of results difficult.

Thus, a research agenda for future research on this topic includes *a more empirical exploration of scaffolding in gamified learning environments in diverse educational levels and disciplines* (e.g., beyond STEM), especially dynamically tackling all three elements of scaffolding (i.e., comprehension diagnosis, guidance calibration and support fade) and meta-cognitive purposes - which has not been explored yet (as per RQ1); *a more empirical understanding of which motivational affordances are more appropriate to scaffolding* in comparison to overall gamification (as per RQ2); *a more consolidated theoretical foundation to support the implementation of gamified scaffolding* both in terms of gamification frameworks and educational and psychological theories to determine if gamified scaffolding can support learners' autonomy, relatedness and competence (SDT), whilst reducing cognitive load (as per RQ3). Finally, *analysing the effects of gamified scaffolding with more methodological rigour*, using well-documented and replicable experimental design, validated measurement instruments, with larger samples and in long-term periods (as per RQ4).

6. Conclusion

This paper described the state-of-the-art of gamified scaffolding through a scoping literature review. We described that the main methods to scaffold information are to provide feedback or to divide the learning into levels that increase in difficulty and that motivation is often the main purpose for implementing scaffolding (RQ1). Gamification and specifically the addition of motivational affordances supports the scaffolding objectives when it is carefully designed and implemented (RQ2). There is no consistent method or framework yet to successfully combine these pedagogies and currently, gamification aspects tend to take preference in the design considerations (RQ3). Scholars choose to combine psychological and behavioural outcomes of which motivation and performance are the preferred choice (RQ4).

The combination of gamification with scaffolding is still a relatively new research area, but the results show steady growth in interest and the innovative ways in which scholars are combining these pedagogies are encouraging. When scaffolding was addressed by scholars, it was used in the broad sense of the term to mean general support overall and a clear distinction between contingency, transfer of responsibility and the fading of support was not evident in any study included in the review. Different methods to scaffold learning were applied, such as templates, offering additional information or staggering the release of information, but the most applied method is dividing the learning into levels to control the increase in difficulty. Scholars added gamification to the scaffold to improve learner motivation, explain concepts or offer strategies on how to solve problems.

From the results, it is clear that the combination of scaffolding and gamification supports learning and leads to higher learner engagement, but it is not yet clear what should be combined and how these elements should be combined to consistently achieve positive outcomes. Tapping into the intrinsic motivation of learners with the addition of game affordances in the scaffold agrees with prior studies on gamification for improved engagement. However, further empirical investigation is necessary to confirm the strength of this link and the specific game affordances that support the scaffolding of learning.

As with any study, this one is not without its limitations. Our search string did include games or GBL, but we included only the literature published under gamification in this study. This allowed for an in-depth analysis of how this concept has been applied and whether scholars see gamification as an umbrella concept that includes both games and GBL. In a future iteration of this research, we plan to include studies that focus on either one of the three concepts (gamification, games and GBL) which should offer further insights as to how these concepts have been applied and the methods utilised to combine these teaching strategies, the methodologies implemented to achieve this combination and the outcomes achieved in this combination. While following a careful protocol with three researchers in the area, all studies were classified and coded according to one single researcher's experience which could have created an internal validity threat. Furthermore, while describing the state-of-the-art on the intersection between gamification and scaffolding in teaching-learning processes, we consciously decided to not provide guidelines on how future applications of the results should be conducted, given that the limited amount of included studies did not go through predefined quality assessment criteria.

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