Learning Landscape in Gamification: The Need for a Methodological Protocol in Research Applications

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Abstract

In education the term gamification refers to of the use of game design elements and gaming experiences in the learning processes to enhance learners' motivation and engagement. Despite researchers' effort to evaluate the impact of gamification in educational settings, several methodological drawbacks are still present. Indeed, the number of studies with high methodological rigor is reduced, and consequently, the reliability of results. In this work, we identified the key-concepts explaining the methodological issues in the use of gamification in learning and education and we exploited the controverses identified in the extant literature. Our final goal was to set-up a check-list protocol that will facilitate the design of more rigorous studies in the gamified learning framework. The checklist suggests potential moderators explaining the link between gamification, learning and education identified by recent reviews, systematic reviews, and meta-analyses: the study design, the theory foundations, the personalization, the motivation and engagement, the game elements, the game design, and the learning outcomes.

Introduction

Educational games were the second most studied educational technology of the last decade, with the amount of papers on educational games growing 255%, and the amount on gamification growing an astounding 2687% (Dubé & Wen, 2021). This research spans a vast range of fields and is not specific to any one educational context (Richter, Raban, & Rafaeli, 2015). According to Landers (2014), both serious games and gamification have as purposes the improvement of learning outcomes, but the processes involved to achieve such gains are quite different. In the serious games field, games are designed to affect learning directly. In other words, the instructional content and activities within the serious game are tantamount to learning

activities (Landers, 2014). In gamification, game elements are designed to influence learning indirectly by acting on learner behaviors or attitudes (e.g. participants' engagement and motivation), which improves learning as a result (Landers, 2014).

In this work, we focus on gamification without focusing on serious games.

Deterding and colleagues (2011) defined gamification as "the use of game design elements in non-game contexts". Following this definition, the game elements could affect the context experience by increasing the motivation and by augmenting the engagemant.

Similarly, Kapp (2012), Hamari and colleagues (2014), Werbach (2014) define the term gamification as "the process of making activities more game-like". According to Dichev and Dicheva (2017), the specific use of gamification in education refers to the inclusion of gaming elements in the design of learning processes. Indeed, as reported in Zainuddin and colleagues (2020) review, including 46 empirical studies, three were the most relevant positive applications of gamified learning: learning achievement, motivation and engagement, interaction and social connection. Despite the excitement for the positive outcomes in the application of gamified elements in learning and educational contexts, most of the works tend to have inconclusive results (Sailer & Homner, 2020; Bai et al., 2020; Huang, et al., 2020). This point is going to be investigated in the paragraphs below.

It is possible to recognize at least two types of constraints concern the use of gamification in learning and education studies: methodological and specific constraints. Methodological constraints refer to the aspects related to methodological issues that have been emphasized in literature over time, while specific constraints pertain to the key aspects discussed in the literature on gamification.

According to methodological aspects, former literature stressed a lack of understanding of which educational-level should be incorporated for optimal benefits (De Sousa Borges et al., 2014), varying impacts on student engagement depending on intrinsic or extrinsic motivation (Faiella & Ricciardi, 2015; Xu et al., 2021), insufficient empirical data and lack of comparative and longitudinal study designs, underdeveloped theoretical foundations and conceptual ambiguity (Seaborn & Fels, 2015a), small sample sizes, a lack of experimental design, an absence of explicit motivation measurements, and a lack of using validated psychometric instruments (Ortiz et al., 2016; Antonaci et al., 2019; Sailer & Homner, 2020). Moreover, many studies lacked an experimental design including both control and experimental groups (Ortiz and colleagues (2016) Alomari et al., 2019; Ofosu-Ampong, 2020).

Indeed, research on gamification is limited and often lacks controlled experimental designs, with few studies examining the effects of individual gamification elements in a controlled manner (Hung, 2017; Bozkurt & Durak, 2018; Majuri et al., 2018). Dichev and Dicheva (2017) highlighted that studies generally focus on game performance as a measure of the effect of gamification without measuring educational outcomes. Usually, the focus is only on short-term outcomes, simplifying the phenomenon and failuring in taking into account for contextual factors and individual differences, with limited exploration of game design practices, and ethical considerations related to long-term impacts and personal data (Rapp et al., 2019; Zainuddin et al., 2020).

Metwally and colleagues (2021), Nair & Mathew (2021), Behl and colleagues (2022), Nadi-Ravandi & Batooli (2022), and Saleem and colleagues (2022) identified several challenges that need to be addressed. These included a lack of understanding of gamification techniques and instructional theories, a debate about the use of Point-Badge-Leaderboard (PBL) elements,

potentially negative effects on intrinsic motivation, and unclear impacts on learning or knowledge levels. Additionally, the authors highlighted that the lack of a methodologically correct experimental designs, the lack of solid theoretical basis in many studies, as well as multiple technological difficulties, could hinder the effective implementation of gamification in educational activities. By looking at the specific constraints, personalization has been considered by different studies (Aljabali & Ahmad, 2019, Denden et al., 2022, Denden et al., 2022). Aljabali & Ahmad (2019) noted that there is a lack of understanding of how to design game mechanics that promote desired outcomes and cater to individual learner characteristics. Most studies treat gamification as a generic construct and fail to investigate the impact of personalized gamification on learning outcomes (Denden et al., 2022). Additionally, there is a tendency to adopt a one-size-fits-all approach, and the literature is fragmented, with insufficient descriptive statistics for meta-analysis (Oliveira et al., 2022).

Other limitations concern the game design in gamification environments. In general, it is suggested a need for more personalization and integration of motivational and instructional design in gamification. Facey-Shaw and colleagues (2017) emphasized difficulty in comparing the effectiveness of badge designs due to their variety. Lack of formal design support and frameworks for many gamification experiences make it difficult to apply procedures and features of case studies in different contexts (Mora et al., 2017; Laine & Lindberg, 2020). A very recent work of Khaldi and colleagues (2023), noted that on 39 articles investigated, a significant portion of applied gamification research is not rooted in theoretical frameworks nor employs them in the design of gamified learning systems. While some experimental studies endeavor to adapt psychological and educational theories from the literature as gamification approaches, the resulting systems lack clarity. In general, despite the lack of a comprehensive theory of

gamification in education, many theories from social, cognitive, and educational psychology are used to identify how gamification enhances motivation, engagement, and learning. The most widely adopted theory is self-determination theory (SDT), while the flow theory is also relevant for active engagement and learning. The only one specifically developed for gamified learning is Landers' theory of gamified learning (Landers, 2014). Other theories from developmental and educational psychology and social psychology can also be relevant, but it is stated that some gamification research lacks a theoretical framework. Finally, some studies indicated as a critical aspect the limited number of respondents involved in studies, inconsistent findings on the effect of gamification on academic achievement, and different effect sizes found in previous meta-analyses, suggesting that the effectiveness may depend on external and internal factors such as gamification designs, pedagogical contexts, learners' frustration, and distraction (Ortiz-Rojas et al., 2017; Dikmen, 2021; Zhang & Yu, 2022).

This study aims to synthesize existing literature on gamification in learning and education and propose a checklist protocol based on recent evidence to facilitate the design, the production of more rigorous studies, to have more reliable results, and to enhance the quality evaluation of gamification studies in education. This is in response to the recent need for a validated checklist to assess the quality of future research in gamification, as suggested by Metwally and colleagues (2021). The proposed checklist protocol is intended to focus on the most recent evidence and aligns with current needs in the field.

This work has been structured into distinct paragraphs, with each section covering a specific aspect of gamification. Beginning with the methods, we then provide a comprehensive discussion on its efficacy in the context of learning. This discussion encompasses an analysis of the core elements that have been extracted from the qualitative analysis of the review, systematic

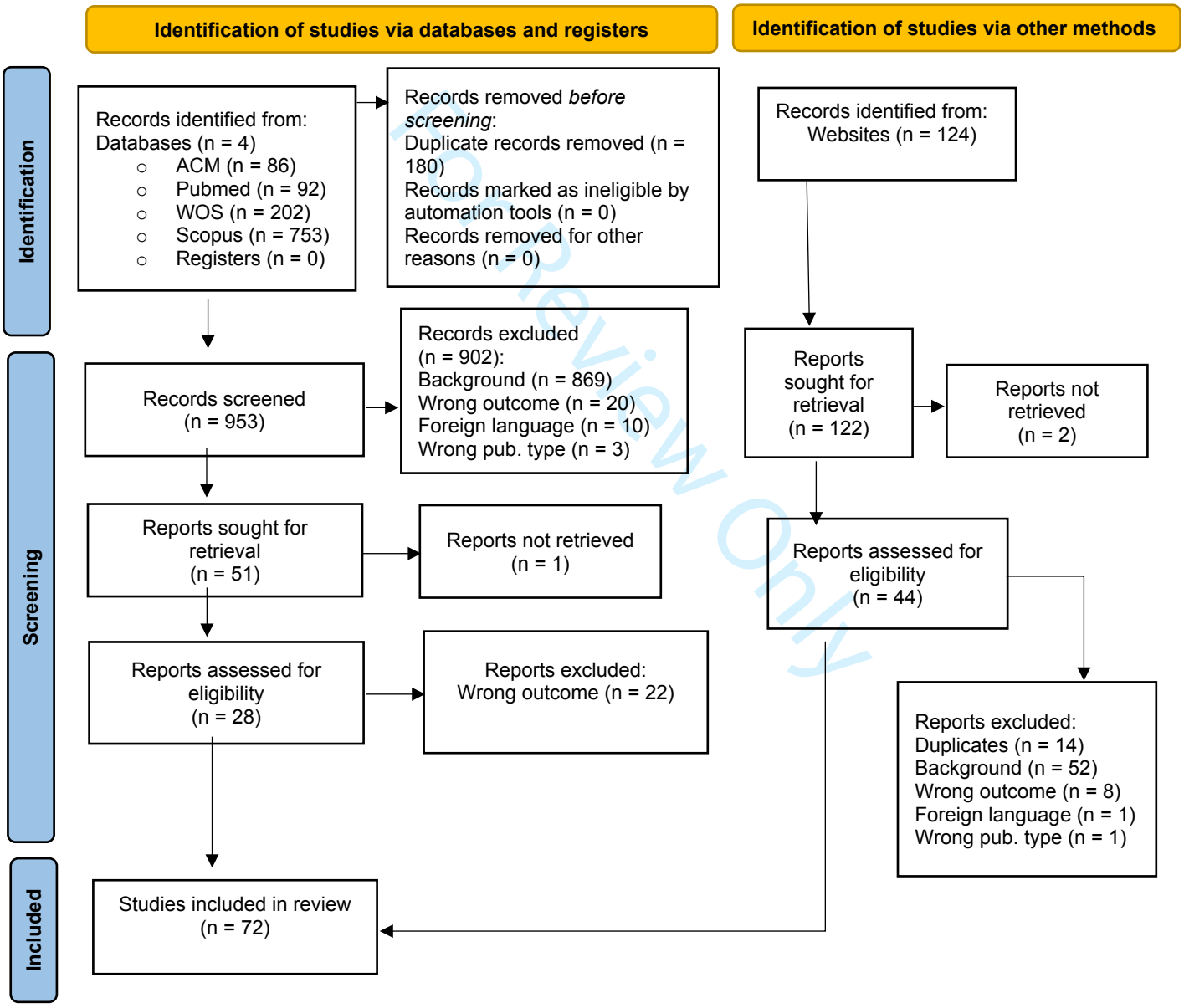
review, and meta-analysis included in this work. Finally, these aspects are used to develop an informative checklist protocol that may serve as a useful resource for researchers and practitioners.

Methods

This work was arranged using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol in its latest version (Page et al., 2021). We pursued a systematic literature search across four academic databases (ACM Digital Library, PubMed, WOS and Scopus) searching for keywords ‘Gamification AND learning’, and filtering for “Review”, “Systematic Review”, "Meta Analysis", "Literature Review", and "Systematic Literature Review" published between 2011 and 2023. The decision to choose this range of years was made to ensure the inclusion of works related to gamification between Detering's definition and the present day. Additionally, Caponetto et al (2014) and Ortiz et al (2016) discovered through literature review that the term "gamification in education" did not appear in paper titles until 2011. The inclusion criteria were that the articles must be written in English. Articles written in languages other than English were excluded. Additionally, single papers, keynote presentations, panel discussions, dissertations, work-in-progress articles, and papers that focused on serious games, game-based learning, revisions, systematic revisions, or meta-analyses that were not conducted within the context of learning, education, or school were also excluded. The revision has been conducted by using Rayyan software (Ouzzani, Hammady, Fedorowicz, & Elmagarmid, 2016). Furthermore, in order to explore additional findings, a bibliographic investigation was conducted using recent meta-analyses as sources, specifically those authored by Bai et al. (2020), Sailer and Hommer (2020), and Huang et al. (2020). The software Connected Papers (Tarnavsky Eitan et al., 2020) was employed for this purpose. Additionally,

the software Elicit (Ought, 2023), an AI-based tool utilizing large language models such as GPT-3, was utilized to perform a literature review. The query posed was "How effective is gamification at promoting learning," with a filter for reviews, systematic reviews, and meta-analyses only. Figure 1 summarize the PRISMA flowchart of present study process.

Fig. 1. PRISMA flowchart of present study process



The inspection through the databases found a total of 1257 works eligible for further investigation. 180 articles have been evaluated as duplicates, and then excluded in the next steps.

A total of 953 were screened for relevance. 902 articles were excluded after title screening. The remaining 51 were processed for abstract and full text evaluation. After that, only 28 were considered relevant. The ground for exclusion is presented in the PRISMA flowchart (Figure. 1). According to the other two methods used for studies identification, 122 were processed and 44 were selected to be eligible for the revision. A total number of three articles were not retrieved. Then, a total of 72 articles were considered for the present work, and according to the findings a checklist has been developed. A table of findings of the articles is included in Supplementary Materials. The subsequent sections outline the development process of the checklist. The initial phase consisted of a qualitative analysis that included descriptive statistics regarding the included articles. Specifically, the frequencies of review, systematic review, and meta-analysis were recorded for the period between 2011 and 2023. Additionally, the core elements or focal points of the articles were identified and their distribution over the years was analyzed. Subsequently, based on the identified core elements, subsections were developed to present the findings, limitations, and key elements that researchers should consider when developing a study on gamification in education and learning and then to create the checklist.

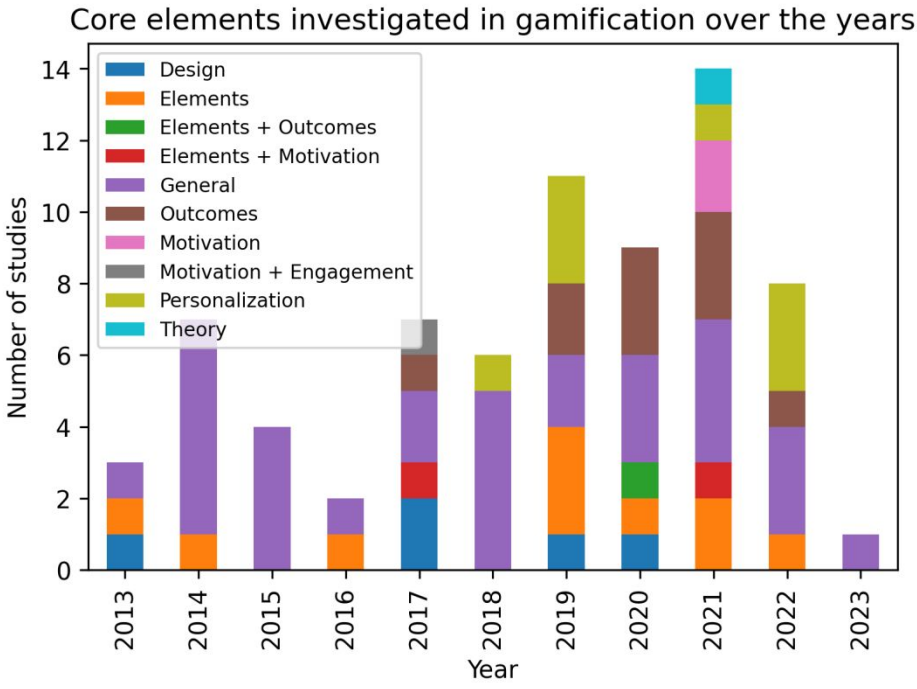
Exploring Frequencies and Core Elements: Descriptive Analysis of Included Articles

Out of the total 72 articles included in this study, 36 were reviews (50%), with 4 of them being critical reviews, while 22 were systematic reviews (30.5%), 11 were meta-analyses (15%), 1 was a systematic deductive analysis (1.5%), 1 was a systematic mapping review (1.5%), and 1 was a systematic meta-review (1.5%).

Furthermore, the articles under investigation were categorized into core elements or focal points, some of which dealt with specific aspects of gamification in education and learning,

while others were a combination of single elements. These core elements include game elements, game design, general aspects of gamification in learning and education, learning outcomes, motivation, personalization (tailored gamification, adaptive gamification), theory, game elements and learning outcomes, game elements and motivation, and motivation and engagement. A concise summary of the fundamental components can be provided by categorizing them into seven fields, which were also employed for the inspection and checklist development. These fields encompass the following: the broad aspects of gamification (comprising the study design), theoretical foundations, personalization, motivation and engagement, game elements, game design, and learning outcomes. To better illustrate the distribution of these core elements over the years, a stacked chart (Figure 1) was developed, with the aim of highlighting trends and tendencies.

Figure 1 Distribution of the articles from 2013 to 2023 according to the core elements investigated.



The year 2021 had the highest number of publications in the field of gamification in learning and education, with a total of 14 articles identified. Moreover, it is noteworthy that several publications dealing with the general aspects of gamification in learning and education have remained constant over the years. However, systematic works that account for the aspects of personalization have received greater attention in recent years, with a more pronounced focus since 2018. Similarly, systematic works covering learning outcomes have gained increased attention, with a rising trend since 2017.

According to the type of publication and the core elements, the Meta-Analyses type of publication focused on learning outcomes (n = 8), general aspects of gamification in learning (n = 1), motivation (n = 1), and game elements and learning outcomes (n = 1). Most of the Systematic reviews focused on investigating general aspects gamification (n= 13), followed by personalization (n = 3), learning outcomes (n = 2), game elements (n = 2), game design (n = 1), theory (n = 1), motivation (n = 1), and game elements and intrinsic motivation (n = 1). Concerning the reviews, most of the studies focused on the general aspects of gamification (n = 14), followed by game elements (n = 7), game design (n = 4), personalization (n = 4), motivation (n = 1), motivation and engagement (n = 1), game elements and motivation (n = 1). All the critical reviews focused on general aspects.

Gamification of learning: what we found and what we should address

Investigating the general aspects of gamification

In this paragraph, we categorize and refer to the literature that covers the general aspects of gamification. These studies broadly investigate the effects or applications of gamification in learning and education without any specific focus on its core aspects.

Nah and colleagues (2013) identified five principles that guide gamification in education. First, games should have multiple layers of goals to ensure goal orientation. Second, recognition of players' achievements enhances their motivation and engagement. Third, positive reinforcement through points or virtual currency can promote learning while negative feedback can offer corrective information. Fourth, competition sustains engagement and focus on the learning task. Finally, a fun component or orientation is crucial for motivating and engaging learners in educational games.

According to Wilson et al. (2015) a gamified system has 3 core elements: an user, a non-game task and a set of game design elements that motivate the user to execute the task.

We present the evidence about the effects of gamification over the years, the methodological concerns, and other aspects like educational level, educational courses, and duration of interventions.

Effects of gamification in learning and education

Gamification has been studied with a focus on enhancing student engagement, motivation, and learning outcomes. While studies have shown the positive effects of gamification, mixed results have been reported depending on the implementation context. Motivation, engagement, self-efficacy, and flow/cognitive absorption are the most significant constructs in gamification research. Additionally, gamification has been shown to improve learning achievement, social connection, creativity, and self-directed study. However, the effectiveness of gamification in promoting learning and participation is still debated in literature, with weaker statistical differences observed between gamified and non-gamified environments.

In more detail, De Sousa Borges et al. (2014) found that previous research on gamification in education has mainly focused on evaluating student engagement, while Caponetto et al. (2014) reported that gamification techniques are also used to develop attitudes and behaviors such as collaboration, creativity, and self-directed study. Several studies (Gerber, 2014; Hamari et al., 2014; Surendeleg et al., 2014; Faiella & Ricciardi, 2015; Sanmugam et al., 2015) have provided empirical evidence supporting the effectiveness of games in enhancing learning, engagement, and motivation. However, Seaborn and Fels (2015), Ortiz et al. (2016), and Dichev and Dicheva (2017) have noted that the effectiveness of gamification varies depending on the implementation context, resulting in mixed results.

According to Inocencio (2018), motivation, engagement, self-efficacy, and flow/cognitive absorption are the most significant constructs in gamification research, as they have consistent theoretical frameworks and reliable scales. While satisfaction and attitude are commonly used, their effectiveness is not as strong. Majuri et al. (2018) found a generally positive effect of gamification, although there is also a substantial amount of research with mixed or null results. Indriasari et al. (2020) described gamification as having positive effects on student engagement, and Kalogiannakis et al. (2021) identified motivation and engagement, learning achievements, and social interaction as the most affected learning outcomes.

Zainuddin et al. (2020) found that the positive themes that emerged from gamification studies included learning achievement, motivation and engagement, and interaction and social connection. Manzano-León et al. (2021) added also positive effects on student academic performance at different educational levels, especially in university education where academic achievement is emphasized. Similar results have been highlighted by Metwally et al. (2021). For the authors, gamification can enhance motivation and engagement in education, particularly

through extrinsic rewards such as achievement and progression, and improve various aspects of children's learning, including cognition, skills, social-emotional abilities, and attitudes.

Nair & Mathew (2021), corroborated the notable positive effect on gamification on learning outcomes, learner motivation, and engagement. In most studies, gamification was found to have a significant impact on learning, with 47 studies exhibiting statistically significant outcomes in the dependent variable. These positive outcomes have been substantiated by Saxena & Mishra (2021) and Devendren & Nasri (2022) in classroom setting. A recent work of Nadi-Ravandi and Batooli (2022) tried to summarize evidence from a sociometric, content and co-occurrence perspective for studies between 2000 and 2021. Authors reported how the application of gamification in education is still challenging due to inconclusive or contradictory results. In gamified education, motivation, learning, and engagement are the most important concepts. Benefits include increased learner competition, practical skills, and perceived learning. Increased participation can improve learning skills and academic achievement. While educational interventions have been effective in promoting learning, motivation, and participation, most studies did not definitively establish the effect of gamification, and weaker statistical differences between gamified and non-gamified environments were observed.

Methodological issues and concerns

Over the years on research in gamification in learning and education several concerns about methodological issues have been substantiated. These issues include small sample sizes, lack of validated measurements, unclear reporting, and absence of control groups. A need for more validation research to test innovative gamification techniques and methods is even more clear, as well as established guidelines on how to effectively implement gamification in education. Despite efforts to develop more engaging and effective gamified systems, there is a lack of

methodological rigor, and a common language is needed for research. However, with the rapidly evolving field, there is also a need for higher quality studies that include two groups with pre-test and post-test.

Carefully, De Sousa Borges et al. (2014), Devers & Gurung (2014), Faiella & Ricciardi (2015), and Ortiz et al. (2016) identified a need for more validation research to test innovative gamification techniques and methods. The authors reported studies often had methodological limitations, including small sample sizes, lack of validated psychometric measurements, absence of control groups, unclear reporting of results, short experiment timeframes, and no multi-level measurement models. Dichev and Dicheva (2017) found inconclusive results in the most of studies investigated, largely due to methodological inadequacies. They suggested a lack of established guidelines on how to effectively implement gamification in education, and an inadequacy about the existing high-quality evidence on its long-term benefits. Bozkurt and Durak (2018) reported that nearly half of the articles lack theoretical or conceptual frameworks. In addition, also more recent articles, have also raised concerns regarding methodological limitations in gamification research. Koivisto and Hamari (2019), Rapp et al. (2019), and Metwally et al. (2021) highlighting a lack of theoretical and methodological rigor (lacks control groups, clear reporting, adequate sample sizes, and experimental timeframes) despite efforts to develop more effective and engaging gamified systems. They emphasized the need for a common language, the use of a broader range of theories and the use of rigorous scientific validity methods constructs in gamification research in learning and education. Nadi-Ravandi & Batooli (2022), suggested that those drawback elements (lacks well-controlled empirical studies or high quality studies considering for example two groups with pre-test and post-test, and scarcity of methodological rigor are typical of areas of research still in development as

gamification in learning and education actually is. Unfortunately, this aspect results in a very low number of eligible studies to develop quantitative analysis compared to the overall published, the presence of inconsistent, contradictory results, and on focusing of elements the effect of which is not reflected in the quantitative analysis.

Educational levels

Regarding the educational levels fostered by gamified research and applications, it has been observed that most of the research has been conducted in higher education, with very limited studies focusing on primary education. Empirical studies on gamification have predominantly been carried out in university settings, with a primary focus on adult participants. Consequently, there is a lack of research on the use of gamification in K-12 education (Dichev & Dicheva, 2017; So & Seo, 2018; Metwally et al., 2021) which highlights the need for further exploration in this area.

Exhaustively, De Sousa Borges et al. (2014), and Caponetto et al. (2014) noted that most of the gamification research in education has centered on higher education, mainly in the university setting, with few studies conducted in elementary education. On a total of 51 papers investigated, Dichev and Dicheva (2017), found that 44 were centered on the university level and only 7 on K-12 education. Among the K-12 studies, 3 involved elementary school students, 2 focused on middle school students, and 2 examined high school students. Similar results have been corroborated by Ortiz-Rojas et al. (2017). On a total of 23 articles investigated, most research focused on higher education (19), followed by high school (2) and middle school (2). So and Seo (2018) identified significant research gaps in educational game research in Asian K-12 schools. Kocakoyun and Ozdamli (2018), and Zainuddin et al. (2020) found that most studies have concentrated on adult participants, or higher education students. A slightly different findings

have been found by Huang et al. (2020). The most of research on gamification in formal education has been carried out with undergraduate students (k=13, n=1724), followed by K-12 students (k=10, n=920). Kalogiannakis et al. (2021), and Metwally et al. (2021) concluded that the focus on gamification research in K-12 education is limited as suggested in the previous years, confirmed that most studies involved students from higher or secondary education. Similarly, A meta-analysis of Dikmen (2021) between 2010 and 2020 in Turkey, revealed that the studies analyzed were conducted across middle school, high school, and university levels. However, no studies on the impact of gamification on academic achievement were found in primary schools.

Educational Courses

From the beginning of gamification research on learning and education, computer science and information technology, engineering, and management are primary contributors. However, the recent literature suggested there is emerging interest from the fields of Arts and Humanities, Environmental Science, and Psychology (Saxena & Mishra, 2021).

In depth, Dichev and Dicheva (2017) examined 32 academic studies organized into six categories: CS/IT, Math, Multimedia/Communication, Medicine/Biology/Psychology, Languages, and Others. STEM domains comprised most studies, accounting for 19 out of 23 studies noted by Ortiz-Rojas (2017), and computing had the largest share (39%) of fields involved according to Limantara et al. (2019). Business, science, medical, and accounting fields each constituted 9% of studies, while remaining studies spanned various fields including art, humanities, mathematics, language, and education. Indriasari et al. (2020) found that Science, Technology, Engineering, and Mathematics (STEM) are frequently reported areas for gamified peer review activities, while Metwally et al. (2021) identified Computer Science (CS) and

Information Technology (IT) as the most commonly studied subjects in gamification research and Saxena and Mishra (2021) proposed emerging interest in gamification from the fields of Arts and Humanities, Environmental Science, and Psychology.

Duration of interventions

Regarding the duration of gamification interventions, the literature has not extensively addressed this aspect. However, some meta-analyses have used the duration as a moderator to evaluate the impact of gamification on learning outcomes (Kim & Castelli, 2021; Yıldırım & Şen 2019). As noted by Zainuddin et al. (2020), most studies have been conducted within a few weeks or months. Even if Ortiz-Rojas et al. (2017) identified a clear tendency among researchers to avoid a novelty effect by conducting longer interventions, Saputro et al. (2017), Saxena and Mishra (2021) and Alsawaier (2018), stated that longitudinal studies are necessary to assess the actual impact of gamification in motivation, engagement and learning outcomes.

Focusing on personalization

In recent years, there has been a growing interest in personalization in gamification for learning and education, which is in response to often inconsistent and conflicting research results in the field. Studies depicted in this paragraph have shown that gamification effectiveness is dependent on individual characteristics such as demographic variables, expectations, learning style, behavior, and skill/knowledge. Personalized gamification has the potential to improve the learning experience by recognizing and catering to the diverse needs of learners, to enhance motivation and performance. Moreover, understanding different learning styles is essential for designing and delivering personalized interventions that yield optimal outcomes. However, the effectiveness of gamification personalization in improving students' learning outcomes remains inconclusive. It is essential to cater to individual learners' needs to ensure gamified learning

success, and educational designers need to acquire an empirical understanding of outcomes, learning objectives, and content to enhance the effectiveness of gamification in education.

While gamification has been shown to have a positive impact on education, it is important to note that negative effects may arise due to individual differences and behaviors (Denden et al., 2022; Saleem et al., 2022).

Thoroughly, in one the first works on this aspect, Hamari et al. (2014) hinted to customize gamified learning to accommodate individual differences among students and Sanmugam et al. (2015) proposed to use the Bartle's player motivation types to assist in recognizing and addressing different student skills and personalities, which helps identify user types for the system.

According to Dichev and Dicheva (2017), Ortiz et al. (2016), Hung (2017), Caporarello et al. (2019) and in more recent years by Denden et al. (2022), Bennani et al. (2021), and Oliveira et al. (2022), the effectiveness of gamification was found to be dependent on individual characteristics and needs such as demographic variables, gender, personality traits, learning types, gaming frequency, player types, individual study design, expectations, culture. To address the unique needs of individual learners, gamification requires customization of game elements. Oliveira et al., (2022), analyzed 21 studies from various countries to assess the impact of personalized gamification on learning outcomes. Most studies focused only on gamer types for personalization and ignored other important factors such as culture and gender.

Regarding the methods implemented in literature to personalize the gamified environment, Aljabali & Ahmad (2019), and Rozi et al. (2019), noted the Felder-Silverman Learning Styles Model (FSLSM) and Kolb's learning style model as the most used learning style models. Bartle's player type has been used to identify different player types, while the Five

Factor Model (FFM) has been deeply used to examine personality traits. Hallifax et al. (2019) reported that there are two main types of adaptive gamification systems in education: static and dynamic. Static systems adapt game elements based on a learner profile, while dynamic systems adapt based on learner activity. Moreover, in recent years other areas that investigate the impact of personalization in gamification interventions have been included, as ontology, artificial intelligence, and intelligent tutoring systems (Aljabali & Ahmad, 2019).

The findings revealed that the personalized mode had higher engagement levels and learning outcomes compared to the non-personalized mode, and improve users' satisfaction (Behl et al., 2022), and has been showed to improve learning motivation and achievement in elementary students (Aljabali & Ahmad, 2019). Differently, Oliveira et al. (2022) noted that while tailored systems were more effective in certain situations, non-tailored systems were more effective in others, highlighting the importance of adapting gaming features to increase learner engagement. Moreover, customization to the learner's proficiency level has been seen to prevent frustration and monotony (Saxena & Mishra, 2021). Whereas Aljabali & Ahmad (2019), found extroverted and introverted individuals perceived the playfulness of leaderboards differently.

However, the effectiveness of gamification personalization in improving students' learning outcomes remains unclear (Oliveira et al., 2022).

Focusing on motivation and engagement

Enhancing motivation and engagement are two of the most important objectives of gamification in learning and education. According to Brooks et al. (2012), motivation guide the behavior and decision-making while engagement is a dynamic force associated with various actions and tasks (Frydenberg et al., 2005). Existing research indicates that it is important to evaluate the

motivation levels and intrinsic motivation of learners. Additionally, Limantara et al. (2019) proposed the "Model of Student Participation" which considers how students were enrolled in the study and their underlying motivation for participating in the gamified study. In general, the findings depicted in this paragraph suggest that the impact of gamification on motivation remains inconclusive, and incorporating game elements in learning environments can significantly enhance student engagement. A recent meta-analysis of Mamekova et al. (2021) suggests that gamification can enhance motivation to learn, but only for about one-third of students. Nevertheless, as suggested by Ortiz-Rojas et al. (2017), there is a need of assessing the motivation explicitly in the future studies in gamification in learning and education. One direction could be the motivation evaluation by using psychometrically validate measures like the Intrinsic Motivation Inventory (IMI) (Ryan, 1982) as suggested by Seaborn & Fels (2015) or other validated measures the authors can find in the following relevant papers (Mayer et al., 2007, Touré-Tillery & Fishbach, 2014).

In-depth, in one of the first works on this aspects, Glover (2013), but also in later (Koivisto & Hamari, 2019; Mohammed & Ozdamli, 2021) suggested that the careful implementation of gamification can motivate learners to complete activities and promote desirable behavior while discouraging undesirable behavior. The crucial factor to consider when evaluating the usefulness of gamification for a group of learners is their level of intrinsic motivation (Sanmugam et al., 2015). If their intrinsic motivation is already high, the addition of extrinsic motivation through rewards could have a counterproductive effect, making gamification unsuitable in such a scenario.

Xu et al. (2021), out of the 58 studies reviewed, 35 studies (59.32%) found that gamification improves motivation, while 3 studies (5.08%) found that gamification did not

improve motivation. For the remaining 20 studies (33.9%), results were either inconclusive or not relevant to the research question of this study. Furthermore, 7 out of 10 studies found that gamification improves intrinsic motivation. Similar results have been found in a meta-analysis of Mamekova et al. (2021). In the study the authors included 7 articles between 2011-2021. They suggest that gamification in education can enhance students' motivation to learn, but only for about one-third of the students. In addition, the effectiveness of gamification might vary depending on whether the game type is appropriate for the learning content.

Sailer & Homner (2020), in their meta-analysis found a significant, small effect of gamification on motivational (Hedges' g = 0.36, SE = .09, p = < .01, 95% CI [0.18-0.54]) learning outcomes with an additional significant and substantial amount of heterogeneity (I^2 = 75.13%, respectively, Shamseer et al., 2015). Concerning the moderators, gamification interventions lasting half a year or less showed significantly larger effects on motivational learning outcomes (g = .59 [.39-.59], k = 6, n = 932) than intervention lasting one day or less (g = .19 [-.07-.45], k = 9, n = 1145). Further, the effects in higher education settings (g = .52 [.33-.71], k = 7, n = 1025) and work-related education settings (g = .72 [.25-1.19], k = 2, n = 53) were significantly larger than those found either in informal training or school settings. This is in line with previous research, where contextual factors are found to differentially affect the experience of gamification in each situation (e.g., demographic and personality factors), the associations attached to the task or activity in general, and the temporal and spatial context (Majuri et al., 2018). Moreover, effects differed between experimental and quasi-experimental studies; where the latter showed a significant medium-sized effect compared to the non-significant effects of the former. However, this pattern changes if only studies with high methodological rigor are included (i.e., experimental designs or quasi-experimental designs with pre and post-tests) (21).

Zhang & Yu (2022), found gamification has varying effects on different types of motivation. Overall, across 10 studies, gamification showed a moderate effect on motivation (Cohen's d = 0.77; p < 0.001; 95%CI [0.53, 1.01]; k 0 10, I^2 = 77.4%). Regarding the intrinsic motivation, the authors found a positive effect of gamification (Cohen's d = 0.64; p < 0.001; 95%CI [0.37, 0.91]; k = 5; I^2 = 66.9%), observed also in extrinsic motivation (Cohen's d = 0.92; p < 0.001; 95%CI [0.50, 1.34]; k 0 5; I^2 = 84.4%).

Regarding the student's engagement, Alsawaier (2018), noted that incorporating game elements, and to design gamified courses with appropriately challenging tasks into learning environments may significantly enhance student engagement, but the impact on motivation remains inconclusive. However, no longitudinal study investigated the most effective game components that promote intrinsic motivation.

Focusing on game elements

Game elements in educational activities, has shown to promote a sense of enjoyment, challenge, and achievement among students. Game elements such as leaderboards, levels/milestones, challenges/quests, badges, immediate feedback, social engagement loops, teams/social dynamics, and visual 3D/sound can enhance engagement, motivation, and involvement in learning. While points, badges, and leaderboards remain the most common game design elements used to enhance motivation, other elements like collaborative work, virtual maps, and skill trees have also been proposed. The effects of game elements on motivation, attitudes, and performance vary depending on gender and personality, and each game element should be carefully selected based on rigorous research. Studies have found an overall slightly

positive effect of gamification on student learning outcomes, with leaderboard, badges/awards, and points/experience employed in most studies. However, studies not using leaderboard resulted in a higher statistically significant effect size than those studies that did use it.

Exhaustively, in one of the first work on gamification and game elements, Nah et al. (2014), noted that gamification offers various elements such as leaderboards, levels/milestones, onboarding, challenges/quests, badges, immediate feedback, social engagement loops, teams/social dynamics, rules, marketplace/economies, visual 3D/sound, avatars, customization, narrative context, and roleplay that can improve user engagement in learning. These components can provide a sense of achievement, reward, personal control, social interaction, and meaning to learning tasks, while also simulating real or fantasy worlds and teaching abstract concepts or subjects. Additionally, storytelling through narrative context can induce psychological responses and drive fulfillment of goals, ultimately enhancing user motivation, focus, and involvement in learning.

Ortiz and colleagues (2016), Saputro et al. (2017), Alomari et al. (2019), Antonaci et al. (2019), Ofosu-Ampong (2020), Huang et al. (2020), and Xu et al. (2021) indicated that gamification research commonly combines elements like badges, points, and leaderboards (PBL) along with challenges, levels, and avatars. The PBL triad have been found to maintain student engagement and motivation, create a sense of competition, and improve learner performance (Alomari et al., 2019; Antonaci et al., 2019). However, Dichev and Divheva (2017) stated that relying solely on the use of points, badges, and leaderboards may not be sufficient to address the relevant motivational factors.

Antonaci et al. (2019), found that the effects of badges may differ based on gender and personality. Badges can be utilized to establish clear goals or encourage social comparison.

Leaderboards have been found to positively affect attitudes towards gamification, learning performance, engagement, enjoyment, and goal commitment, especially in challenging tasks. Like badges, the effects of leaderboards vary depending on personality, and can facilitate social comparison, which positively influences performance by providing information on user points and stimulating competition among users. Leaderboards were found to increase positive competition and motivation in 32 studies, but some students felt less motivated due to the added competition (Xu et al., 2021). Bernik et al. (2022), highlighted the use of a leaderboard and top-scoring student list, along with continuous feedback, virtual meetings, and a socially oriented system are recommended for effective gamification.

Points, scores, and rankings in gamification has been found to have positive effects on motivation, engagement, performance, and emotional states. Limantara et al. (2019) suggested points as the most motivating game elements for assignments. However, these effects may vary depending on gender and personality, but the use of points can foster social comparison and encourage users to undertake challenging tasks.

The PBL triad were found to create extrinsically motivating conditions to encourage intrinsic motivation (Xu et al., 2021).

Rewards, progress bars, feedback, and avatars are also considered effective in promoting motivation and engagement in learning. Saputro et al. (2017) noted that intrinsic motivation can be increased through a sense of autonomy, competence, relatedness, and purpose, which can be fostered through various game design elements, such as collaborative work, virtual maps, and skill trees. Howard-Jones & Jay (2016) focused on the role of reward in educational games by a cognitive neuroscientific perspective. They stated interventions using uncertain rewards can be

effective but have limited evidence. However, understanding how rewards impact memory formation can aid in implementing gamification in education.

Huang et al. (2020) investigated n = 30 studies trying to give some indications about the effects of game elements on learning outcomes. An overall slightly positive effect has been found (Hedges' g = .464, p < .001, 95% CI [0.244, 0.684]) with a substantial amount of heterogeneity (I^2 = 88.21%). Interestingly the authors found that studies that not using leaderboard resulted in a higher statistically significant effect size (g=.771 [.286-1.256], k = 8, n = 724) than those studies that did use it (g=.358 [.107-.608], k = 23, n = 2359) and similar effect size has been found between using or not badges/awards, points/experience design elements. A significant medium effect size has been found in the use of responsive feedback (g=.509 [.185-.833], k = 19, n = 2148). The presence of timed activities showed a small effect size (g=.236 [-.199-.670], k = 6, n = 710) not statistically significant compared to the absence (g=.529 [.268-.790], k = 24, n = 2373). Moreover, the presence of a collaboration design element showed a significant effect size (g=.609 [.222-.997], k = 9, n = 719), while the absence of competition showed a major effect size (g=.590, k = 9, n = 665) compared to the presence (g = .412, k = 21, n = 2318). Finally, the highest effect size was observed in the use of quests/missions/modules (g = .649 [.279, 1.02], k = 12, n = 1142).

In addition, a significant medium effect size has been found in undergraduate students (g = .638 [.378-.898], k = 13, n = 1724), while the K-12 students (g = .306 [-.156-.767], k = 10, n = 920) showed a non-significant one.

Cavalcanti et al. (2021) focused the work on investigating the effects of feedback on students' performance activities. They found that 65% of the papers concluded that feedback had a positive impact on students' performance, and 41.26% used feedback to support self-regulation.

Also, Willert (2021), focused on feedback in gamified education. It found six different types of feedback can be implemented in educational games. Formative feedback assesses the quality of a student's responses and can enhance their competence, while summative feedback summarizes the student's achievement status or end of a course unit and can influence future decisions. Immediate feedback is provided virtually during tests or given soon enough after submission to impact the student's next task. Self-regulation feedback supports students in monitoring and adjusting their actions towards learning goals. Scaffolding provides support to students in their learning process and can be gradually faded out as competence increases. Social or peer feedback is when feedback is given to tasks and assignments from one student to another.

Investigating 50 articles, the author that feedback types are distributed as follows: 31 are formative/process, 19 are summative/corrective, 17 are immediate/rapid, 12 are self-regulation, 9 are social/peer, and 4 are about feedback through scaffolding. In general. the purpose of implementing feedback is to enhance student engagement, give a better sense of progression and goal orientation, help students in their work or progress, improve the correctness of submitted assignments, increase student motivation, enhance perceived competence, empower students, and add enjoyment and fun to the learning process. The feedback implementation allowed an overall satisfaction with the new course or system, better engagement, higher rates of submitted assignments, increased student motivation, better self-pacing of learning, qualitative improvements in code, higher student satisfaction, and better onboarding for inexperienced participants.

However, some focal points have been highlighted. Alomari et al. (2019) suggested how each game element should be carefully selected based on rigorous research. Ofosu-Ampong

(2020), emphasized the role of having a clear experimental approach, without it is difficult to determine which game elements are most effective for a specific activity and group of learners.

Finally, Saleem et al. (2022), suggested that the effectiveness of gamification in education remains a contentious issue as incorporating gamification elements has not resulted in significant improvements in students' group cohesion, talent, motivation, and intrinsic drive.

Including game design

Game design consider the underlying design principles that make games engaging. Effective gamification requires a deep understanding of game design principles and how they can be applied to learning objectives. The literature suggests that effective gamification in learning requires a deep understanding of game design principles, as providing students with freedom to fail, offering frequent feedback, designing progression, and using storytelling. Badge system design is critical and should consider functions, structure, and design. Successful game design requires defining clear objectives, considering feasibility, and understanding stakeholders. Psychological factors such as fun, motivation, and social interaction are also important. Finally, game designers should engage diverse players by providing challenges at adjustable difficulty levels, allowing sufficient time to solve challenges, promoting creativity and self-expression, and employing social play, storytelling, and fantasy.

One of the first works on the application of game design principles to gamification in learning and education has been carried out by Stott & Neustaedter (2013). The authors noted that these principles can create a more enjoyable and effective learning experience for students. These include providing students with the freedom to fail and experiment without fear of irreversible

damage, offering rapid and frequent feedback, designing progression in the form of scaffolded instruction or levels, and using storytelling to contextualize learning elements.

Several years later, Facey-Shaw et al. (2017) and Park & Kim (2019), presented works focused on the design of badge system. According to the authors, badge system design is a critical element of the process of motivating, recognizing, and showcasing formal and informal learning using digital badges. It has been suggested that badge systems have three core dimensions, including the functions or purpose of badges, the structure of badge systems, and the design and interaction with badges. Park & Kim (2019), suggested to focus on three conditions when developing badge design: distinguishing between physical and conceptual learning activities, between individual and interaction-induced learning, and reviewing the time and effort required for earning badges. The study proposes eight badge types for three badge design conditions with a statistically significant difference between them ($\chi^2 = 1117.7; p < .001$). The authors, indicating that badges are useful tools for promoting self-directed learning and providing various benefits such as flexible learning environments, goal setting, progress tracking, and planning. Moreover, badges have been shown to positively impact critical thinking, teamwork, leadership, and other skills and knowledge. However, they may not always be effective in instilling interest. Indeed, learners were generally comfortable displaying badges within a social learning environment but less comfortable sharing badges with external audiences (Facey-Shaw et al., 2017).

Other than badge design, Mora et al. (2017), retrieved ten relevant ingredients for successful game design. These include self-representations, three-dimensional environments, narrative, feedback, reputations, ranks and levels, marketplaces and economies, competition under rules, teams, communication, and time pressure. Despite that, other have been highlighted in their

work, including engagement cycle, end game, rules, and storytelling, the importance of defining clear objectives, considering feasibility and investment, and understanding stakeholders in the design process, the psychological factors such as fun, motivation, social interaction, and desired behaviors. Finally, Laine & Lindberg (2020), identified 56 motivators that contribute to motivated engagement in educational games, which are grouped into 14 classes based on their similarities. The authors suggested game designers engage diverse players by providing challenges at adjustable difficulty levels, favoring simple challenges, and allowing sufficient time to solve challenges. Players should have the ability to make choices and use input mechanisms suitable for them. Game designers should foster creativity and self-expression, promote exploration, ensure fairness, and set clear and achievable goals. The game should be relevant to the player's context and involve game resources to increase engagement. Additionally, social play, storytelling, and fantasy should be employed. Finally, the authors claimed that many of the motivators were initially intrinsic, but game mechanics supporting these motivators can produce different motivational results depending on the context of use.

Focusing on learning outcomes (cognitive, behavioral, and affective)

Gamification is a technique that has been used to improve learning outcomes (cognitive, behavioral and affective) in various educational settings. However, research has yielded mixed results. This paragraph depicted some of the most relevant findings.

In-depth, Ortiz-Rojas et al. (2017) investigated the effects of gamification on learning performance. They found that although only 9 studies have demonstrated a positive impact, it is crucial to examine why the remaining 14 studies have shown negative or mixed results. The

authors, stated that various factors, including mediating variables, the choice of measurement instrument, sample size, and study duration, could have influenced the outcomes.

Sailer and Homner (2020), investigated the effects of gamification on cognitive, and behavioral learning outcomes. The results yielded a significant, small effect of gamification on cognitive (Hedges' g=0.49, SE = .10, p < .01, 95%CI [0.30-0.69]), and behavioral (Hedges' g = 0.25, SE = .11, p = < .05, 95% CI [0.04 - 0.46]) outcomes with an additional significant and substantial amount of heterogeneity (I2 = 72.21%; 63.80% respectively, Shamseer et al., 2015). From the moderator analysis, results indicate that the inclusion of game fiction (g = .41 [.31-.51], k = 3, n = 254) and social interaction, specifically the competition-collaboration combination (g = .70 [.41-.99], k = 3, n = 135), were particularly effective at fostering behavioral learning outcomes.

However, by considering only studies with high methodological rigor, only cognitive learning outcomes showed a small effect of gamification (Hedges' g = .42, SE = .14, p < .01, 95% CI [0.14, 0.68]). But this is a much smaller number of studies (9) and total sample (686) than the more inclusive analysis that contained studies with a lower methodological rigor (22). In addition, no moderators were found to significantly moderate the effects of gamification on cognitive learning outcomes in this more conservative analysis.

Also Kim and Castelli (2021) investigated with a meta-analysis the effects of gamification on behavioral change in education, assessed through test score or participation level. On 18 eligible studies, authors found a moderate significant effect size (Cohen's d = .48, 95% CI [0.33, 0.62]), higher in participation level (d = .60 [.40-.77], n = 15'322) than test score (d = .30 [.03-.18], n = 3059). These results are in line with those found by Sailer and Hommer (2020). In this context, the gamification appeared to be effective both for adults (d = .95 [.70-

1.12], n = 12’455) and K-12 (d =.92 [.29-1.55], n = 146) interventions, while did not for college students (d = .15 [-.04-.35], n = 5780). Concerning the intervention length, those with less 1 hour (d = 1.57 [1.25-1.90], n = 492) was the most effective than 2–16 weeks (d = 0.39, [.21-.57], n = 12’282) and 1–2 years (d = −.20, [-.47-.09], n = 18’381) in behavioral change.

Ritzhaupt and colleagues (2021), through a meta-analysis investigated the impact of gamification in formal education settings on affective and behavioral outcomes. Authors included 19 studies with affective outcomes and 13 with behavioral outcomes. In this work the label affective outcome is analogous to motivational outcome in the work of Sailer and Hommer (2020). Regarding the affective outcomes, a significant medium effect size as with what has been found in the work of Sailer and Hommer (2020) (Hedges’ g = .574, p < .001, 95% CI [0.384, 0.764]). In addition, a high amount of heterogeneity (I^2 = 73.51%) has been found.

In accordance with the rest of literature, leaderboards, badges/awards, and points/experiences were the most frequently observed design elements also for affective outcomes. Leaderboards resulted in a notable effect on affective outcomes (g = .643 [.420-.866], k = 13, n = 1560) than without (g = .397 [.071-.772], k = 6, n = 414). This result suggests how the competition in educational settings has a highest effect size on affective outcomes, while no other statistically significant differences were discovered between the presence and absence of specific game elements. However, it is also true that the others game elements were rarely observed in the studies, suggesting future lines of research.

By considering behavioral outcomes, authors found a significant medium effect size (Hedges’ g = .740, p < .001, 95% CI [0.465, 1.014]) with a high amount of heterogeneity (I^2 = 83.26%). This is in line with what were found by Sailer and Hommer (2020), and Kim and Castelli (2021). Leaderboards, points, and badges were the most frequently game design

elements, but no statistically significant differences resulted with and without each of these. However, other non-frequently used game elements showed more interesting results. The presence of Non-linear navigation gets a statistically significant difference on behavioral outcomes than the absence (g = 1.362 [.903-1.822], k = 1, n = 133). However, this result is based on one study only (n = 133). The absence of adaptivity/personalization (g = .806 [.515-1.096], k = 12, n = 1498) and narrative/storytelling (g = .791 [.482-1.101, k = 12, n = 1397]) get a statistically significant difference on behavioral outcomes than the presence.

Bai and colleagues (2020) conducted a meta-analysis of 24 quantitative studies and a synthesis of 32 qualitative studies, all containing a control condition and meeting MERSQI standards for the field, to examine the impact of gamification on academic learning outcomes in K-12 education. Overall, they found a medium effect of gamification on learning (Hedges' g=0.50, $p < .001$, 95%CI [0.28-0.72]) with substantial heterogeneity (I^2 = 88.2%, Shamseer et al., 2015). To account for the large variance in effect sizes, the moderator analysis included i) the type and number of game elements used, ii) the quality/level of the control group, iii) intervention characteristics (e.g., sample size, subject, duration, flipped classroom or not, integration of gamification into instructional activities or not, use of tangible rewards), and iv) participant characteristics (student level, geographic region). Results indicate that effect size significantly increased with sample size, decreased with interventions greater than one month, was greatest in classrooms from Western Asia (i.e., majority of published works), and did not differ within any other set of moderators.

Their qualitative synthesis highlighted fours reasons students liked to gamification: i) fosters enthusiasm, b) provides performance feedback, c) gives a sense of recognition, and d) promotes goal setting. Also, they identified two reasons students disliked to gamification: not

adding additional utility and causing anxiety or jealousy due to social comparisons/competition. Critically, the large variability in effect size was not explained by the number (1 vs 6) or choice of game elements used. This is likely caused by too few studies meeting the standards for inclusion, with 42 screened out for lacking a control group (13), not meeting the criteria for a gamified course (8) and providing insufficient data (21). Clearly, more gamification studies need to meet inclusion standards to facilitate cross-study comparisons and a better understanding of which game elements matter.

Another meta-analysis of Fadhli et al. (2020), focused on the effects of gamification in different learning outcomes (cognitive, skills, attitude, language, health, and social-emotional abilities). The difference between pre and post test express a positive impact of gamification in fostering learning outcomes in 6-10 years children (Cohen'd = 1.01, 95% CI [0.98, 1.05], k = 6) with an amount of heterogeneity $I^2 = 0.53$. However, the findings cannot be considered conclusive because of the limited number of studies included.

Yıldırım & Şen (2019), conducted a meta-analysis in evaluate the effectiveness of gamification in students' achievements, by using the educational course as moderator, found that gamification's effect on student achievement did not show significant differences in both technology-based and non-technology-based courses. Where technology based courses (N = 15; g=0.482, p = .053, 95%CI [-0.007-0.970]) and non-technology based course (N = 30; g=0.588, p < .001, 95%CI [0.346-0.829]). However, investigating the effects size, seems that non-technology-based courses have a greater advantage in using gamification for academic achievement compared to technology-based courses.

Another meta-analytic work on the effect of gamification in university students' academic achievement, has been conducted by Dikmen (2021) in the Turkic population.

The author incorporated 52 primary studies and discovered a favorable association between gamification and academic achievement (Cohen's d = .862, p < .001, 95% CI [0.68, 1.04], k = 52), with a large amount of heterogeneity (Q_{model} = 266.417, p < .001). Different moderators have been investigated (educational level, educational course, class size and publication years). The analyses showed a non-significant moderator effect of educational level in terms of the effect of gamification on academic achievement. Concerning the educational course, it has been found as a positive moderator, where the largest effect size was observed in the science course (d = .993), while the smallest was observed in the mathematics (d = .416). The class size and the publication years were not considered as positive moderators in this study.

To sum up, the present study corroborated the beneficial impact of gamification on students' academic accomplishment. This finding was supported by Zhang & Yu (2022), research, which demonstrated that gamification enhances learning performance (Cohen's d = 0.85; p < 0.001; 95%CI [0.32, 1.37], k = 6).

However, some meta-analysis have reported different effect sizes, possibly due to cultural differences in gamification of learning and the grouping of courses in previous studies. Bai et al. (2020) discussed the importance of educational levels in moderating the impact of gamification on academic achievement. However, the current study's findings suggest that could be not true. This indicates that gamification can be effective across all levels of students and is not limited to a specific age group. According to educational level, the findings appear inconsistent with those of previous meta-analyses. Indeed, Yıldırım & Şen (2019) grouped the courses as technology-based and non-technology-based. Furthermore, the limited inclusion of subject disciplines in previous studies may have contributed to these differences.

Finally, a systematic review of Nurtanto et al. (2021), corroborated the previous findings on the positive effects of gamification in affective, behavioral and cognitive outcomes. Concerning the affective domain, the authors found that gamification increase enthusiasm, motivation, and other emotional responses. Regarding the cognitive outcomes, gamification has been found to have a positive impact on student retention, Other positive benefits of gamification are related to behavior change, with improvements in teamwork, communication skills, social skills, digital literacy, critical thinking, and digital literacy.

A checklist for research in gamification

Gamification in learning and education is a complex system that involves various aspects, including user characteristics, learning outcomes, system implementation, and the development of elements within the system. Previous paragraphs have discussed the most important characteristics identified in the literature, revealing mixed sentiments regarding the results, key considerations, and methodological constraints. Therefore, the purpose of this paper is to create a checklist, as suggested by Metwally et al. (2021) (see Appendix), that can guide researchers and developers in conducting high-quality research on gamification in learning and education. This checklist considers the most critical elements, moderators and mediators that may impact gamification success, methodological considerations, and essential elements that should not be excluded in the study design. In addition, gamified learning environment is a high-cost process involving different professionals, then giving some starting point could reflect also in a reduction of the production costs. To this end, we turn to findings from the 72 studies investigated.

The checklist was created using key constructs identified according to the present systematic review. Our analysis concentrated on seven primary aspects, namely study design,

theoretical foundations, personalization, motivation and engagement, game elements, game design, and learning outcomes. In total, the checklist comprises 24 items.

Some of them have been structured to have a four-point quantitative Likert scale ranging from -1 to 3 with the idea of directing the researcher in the implementation of the more or less effective elements compared to what we know today contextually to the period in which we wrote this work.

The value -1 of the scale reflects which elements or study design have been seen having a negative impact on learning or in the methodological rigor.

The value 0 reflects elements having a neutral impact on learning or in the methodological rigor, 1 a low positive impact, 2 a medium positive impact and 3 a high positive impact. These values, if related to a learning aspect investigated in the meta-analyses, are mirrored to the effect size discovered, according to Cohen (1992). Furthermore, we have incorporated a point-based system into our approach, which serves as an indicator of the evidence reviewed in the preceding sections. This addition facilitates researchers and practitioners in assessing the quality of their work. Before initiating their research or designing a study, researchers can complete the checklist, which highlights the critical elements. This step will enable them to evaluate the quality of their work using the point-based system, which assigns a score ranging from 0 to 20. A higher score indicates the inclusion of aspects that improve the research's quality and methodological rigor, while a lower score suggests that the study may have overlooked critical factors that are necessary for a rigorous evaluation of gamification's impact on learning and education.

The first set of criteria (items 1-6) concern study design. Due to claims of develop more methodological rigorous experiments, we encourage to set-up experimental or quasi-

experimental studies, employ pre-post assessments, and include control groups (Sailer & Homner, 2020; Seaborn & Fels, 2015, Huang et al., 2020; Bai et al., 2020; Kalogiannakis et al., 2021). In addition, researchers should consider, as control measure, the type of activities the control group has carried out (e.g., passive, active, or no activities) and whether the control groups is equivalent to the experimental group at pre-test (e.g., in previous knowledge).

Other important considerations involve accounting for educational level and course type as covariates, especially when analyzing multiple levels and types of courses. Additionally, there has been a focus on the potential for conducting longitudinal studies to assess the long-term effects of gamification and utilizing a sizable sample to enable more sophisticated analyses, such as mixed or multilevel models.

The item criteria number 7 concern the theory behind gamification in learning and education. In detail, Khaldi et al. (2023), highlighted how many studies lack a foundation in theoretical frameworks and do not incorporate them in the development of gamified learning systems. Then, contextualizing the study results based on a reference theory of gamification in learning and education could enhance the quality and the clarity of the study itself.

The next set of criteria (items 10 - 16) concern personalization aspects. As emphasized earlier, exploring individual behaviors and characteristics has become an essential element in determining which gamification systems are best suited for specific individuals. Gender, personality traits, learning types, gaming frequency, player types, individual study design, expectations, and culture have been identified as crucial factors in this regard. Synthesizing evidence from studies that consider one or more of these personalized elements as moderators can help create more high-quality research on gamification in learning and education. Focusing on player types, researchers studying gaming personality hold that different player types exist

(i.e., different characteristics and preferences for specific game elements) and can affect players perceptions of gamification design elements (Santos et al., 2021). Gaming personality may account for how interactive and engaging gamification may be for some students (Tu et al., 2015). The Bartle Test of Gamer Psychology (Bartle, 1996) or its successor (González Mariño et al., 2018) are frequently applied by researchers to understand and categorize online game players into four gaming personalities, based on their gaming preference.

In recent years, other models have been proposed. The BrainHex Model (Nacke et al., 2011) is based on players' neurobiological characteristics. It consists of seven player types, called archetypes, that typifies a particular player experience. Marczewski (2015) proposed the Gamification User Types Hexad, a model specific to gamification, based on Self-Determination Theory (Ryan & Deci, 2000a), in which six user types are motivated by different combinations of intrinsic or extrinsic motivational factors. At this point, the following question arise: which of these gamer personality models best explains gamification in education is still up for debate and future works is needed to understand if gamer personality is a critical element in gamification.

The criteria number 17 concern the motivation and engagement outcomes. We categorized these outcomes separately because existing literature emphasizes the significance of assessing motivation using psychometrically validated measures both before and after implementing the gamified intervention (Ortiz-Rojas et al., 2017; Seaborn & Fels, 2015). Then, a study that evaluates motivation both before and after implementing a gamified intervention has a higher methodological rigor than one that does not.

The next set of criteria (18-21) concern the effects of game element/s, (Dichev & Dicheva, 2017; Dicheva & Dichev, 2015; Seaborn & Fels, 2015). As reported previously, conducting a gamification study requires the selection of specific game elements by the

researchers (Dichev & Dicheva, 2017). Some of the literature indicates that the use of points, badges and leaderboard are most likely to produce learning outcomes (Limantara et al., 2019; Zainuddin et al., 2020). However, previous reviews contain inconsistent and contradictory results, and found that researchers do not always identify the game design elements used in their study or systematically inspect their impact on learning outcomes (e.g., Bai et al., 2020; Seaborn & Fels, 2015; Alomari et al., 2019; Ofosu-Ampong, 2020). As such, checklist criteria 18 provides researchers with a comprehensive list of game design elements for potential inclusion in their study. Further, the effectiveness of any one game element or combination of elements may vary as a function of other factors (i.e., criteria 5,6,8,11-16), which should be addressed with specific and appropriate statistical analysis accordingly.

Regarding feedback, in accordance with the Self-Determination Theory (Ryan & Deci, 2000a), literature suggests that affective feedback, combined with gamification is linked to positive, intrinsically motivated behavior (Hassan et al., 2019). However, it is still not clear how different types of feedback are related to gamification environment, game design elements, and participants characteristics in improving learning outcomes (Hassan et al., 2019; Seaborn & Fels, 2015b). For this reason, studies of gamification should indicate the presence and type of feedback in their design and investigate it comprehensively (criteria 19).

In the criterion 22 we focused on game design. According to the literature, the effective gamification in learning requires a deep understanding of game design principles (Mora et al., 2017; Laine & Lindberg, 2020). Then, incorporating game design principles in research yields a high quality research level.

In the last criteria (23-24) we summarized evidence derived from the reviews, systematic reviews, and mostly meta-analyses divided for the learning outcomes.

For the behavioral learning outcome, we summarized evidences from the meta-analyses of Sailer and Homer (2020), Kin and Castelli (2021), and Ritzhaupt and colleagues (2021).

Overall, small to medium effect size was found. Interventions less than 1 hour till 16 weeks were the most effective, eliciting a medium to high effect size. Moreover, investigating the effect on the target population the adults and K-12 were the most beneficial with a high effect size, while an inconsistent result was found in undergraduate/college population. Furthermore, the most relevant game design elements were the presence of non-linear navigation, the game fiction, the competition-collaboration, and the active instructions. In addition, a negative effect of adaptivity/personalization and narrative/ story telling was found.

By considering the motivational/affective learning outcomes, we summarized the evidence from the meta-analyses of Sailer and Hommer (2020), and Ritzhaupt and colleagues (2021). Overall, a small to medium effect size was found. The interventions less than 6 months were the most effective, eliciting a medium effect size. Moreover, investigating the effect on the target population the higher/undergraduate students, and the K-12 was those with a medium to high effect size, while an inconsistent result was found in school settings. Furthermore, the most relevant game design elements were the presence of leaderboards, and the competition-collaboration.

By considering the cognitive learning outcomes, we summarized evidences from the meta-analyses of Sailer and Hommer (2020). Overall, a medium effect size was found. Interventions from less than 1 day to less than 6 months were the most effective, eliciting a medium effect size. Moreover, investigating the effect on the target population the higher/undergraduate students, and the students was those with a medium effect size. No game

design element was found to significantly moderate the effect of gamification on cognitive outcomes. This result is consistent with those found in Vermeir and colleagues (2020).

Finally, we considered those effects of gamification on students learning outcomes by investigating the meta-analyses of Bai and colleagues (2020), Huang and colleagues (2020), Dikmen (2021), Yıldırım & Şen (2019), and Zhang & Yu (2022). Overall, a medium or high effect size was found. Interventions less than 1 week or between 1-3 months were resulted to be the most effective, eliciting a medium to high effect size. A medium effect size has been found for both technology-based courses and non-technology based. The class size and the publication years showed a neutral impact. The effect on specific target populations showed a medium effect size for undergraduate students. By considering the game design elements, a medium effect size was found for responsive feedback, collaboration, quests/missions/modules, and for the combination of badges, leaderboards, and points.

Conclusion

Introducing gamification into learning and education is a multifaceted system that necessitates researchers and practitioners to consider various elements for a fruitful implementation. Despite the considerable amount of educational gamification research conducted in the past decade alone (Dubé & Wen, 2021), much of this work has highlighted the need to enhance the quality and methodological rigor of research in this field. In Sailer and Homner's (2020) meta-analysis of 786 studies, 427 (54.3%) were excluded for research design issues or lacking a control group and only 38 (4.83%) were considered sufficiently methodologically robust. Huang and colleagues (2020) excluded 379 articles due to a lacked control group, and only 30 studies were eligible for meta-analysis. The same result was found in

Ruthzaupt and colleagues (2021). In this work 379 studies were excluded due the absence of a control group, or other methodological issues.

This study aims to investigate the necessary elements and propose a checklist protocol for conducting high-quality and methodologically rigorous research in the field of gamification in learning and education. This is based on the evidence presented by a systematic review conducted between 2011 and 2023, which considered reviews, systematic reviews, and meta-analyses.

The evidences showed how seven core elements have to be considered in the implementation process: study design, theoretical foundations, personalization, motivation and engagement, game elements, game design, and learning outcomes.

The necessity of this tool is further reinforced by a recent study conducted by Metwally et al. (2021). The proposed checklist is expected to serve as an initial reference for researchers and developers to conduct studies that encompass the essential elements reported in the literature, in order to design products that are of high quality and methodological rigor.

Moreover, it is important to recognize that this study represents an initial step, as the tool was developed based on the existing literature. Additionally, a forthcoming investigation will focus on the validation of the current checklist.

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Appendix

Enhancing Research Quality on Gamification in learning and education – a checklist protocol for researchers and practitioners	**Points**
Study design	
1) In which country you are developing the study? _____	
2) Which type of Experiment are you planning to condict? □ Experimental (3) □ Quasi-Experimental (2) □ Qualitative (-1) □ Other	 [2] [1] [0] [0]
3) Have you considered a Pre-Post study with two groups? □ Yes (3) □ No (-1)	 [1] [0]
4) Presence of Control Group: □ Yes (3) □ No (-1) The instruction of the control group is: □ Passive (e.g., listening to lectures, watching instructional videos, reading textbooks) □ Active (explicitly prompting the learners to engage in learning activities (e.g., assignments, exercises, laboratory experiments)) □ No instruction Comparisons between the groups at pre-test □ No statistical difference (equivalent groups) □ A statistical difference (non-equivalent groups) □ No comparison	 [1] [0] [1]
5) Educational level targeted: □ Elementary School Students □ Middle School Students □ High School Students □ Undergraduate Students □ Postgraduate Students Are you also considering the specific population targeted as covariate in the analyses?	

☐ Yes ☐ No ☐ No, I used only one population at the same grade	[1] [0] [1]
6) Educational course targeted: ☐ STEM field: Specify: _____ ☐ Non-STEM field: Specify: _____ Are you also considering the specific course targeted as covariate in the analyses? ☐ Yes ☐ No ☐ No, I used only one course in the study	 [1] [0] [1]
7) Have you planned a longitudinal study? ☐ Yes ☐ No	 [1] [0]
8) Have you considered a sufficiently large sample size considering the covariates to be included in the model? ☐ Yes ☐ No	 [1] [0]
Theory	
9) Have you considered contextualizing the results based on a reference theory of gamification in learning and education? ☐ Yes ☐ No Which? ☐ Motivational: ☐ Social-Determination Theory ☐ Intrinsic-Extrinsic Motivation ☐ Expectancy Theory ☐ Goal-setting Theory ☐ Flow Theory ☐ Learning: ☐ Classical Conditioning	 [1] [0]

☐ Operant Conditioning ☐ Theory of Gamified Instructional Design ☐ Social Theory ☐ Socio-Cognitive Conflict ☐ Social Learning Theory ☐ Other: _____ _____	
Personalization	
10) In which country you will plan the study? _____	
11) Are you considering the gender as covariate in the analyses? ☐ Yes ☐ No ☐ No, I used only one population	[1] [0] [1]
12) Have you considered investigating the personality traits in the effect of gamificatio? ☐ Yes ☐ No Which instrument? ☐ Five Factor Model (FFM) ☐ Other _____	[1] [0]
13) Have you considered investigating the learning types in the effect of gamification? ☐ Yes ☐ No Which instrument? ☐ Felder-Silverman Learning Styles Model (FSLSM) ☐ Kolb's learning style model	[1] [0]
14) Have you considered investigating the gaming frequency in the effect of gamification? ☐ Yes ☐ No	[1] [0]

15) Have you considered investigating the player types in the choice of game design elements? ☐ Yes ☐ No Which instrument? ☐ The Bartle Test of Gamer Psychology ☐ BrainHex Model ☐ Hexad ☐ Other _____ _____	[1] [0]
16) Have you considered to use a static or dynamic gamification system? ☐ Static gamification system ☐ Dynamic gamification system	
Motivation and Engagement	
17) To ensure high-quality research in the field, it is essential to conduct an evaluation of motivation using psychometrically validated measures. Have you made arrangements to assess motivation both before and after implementing the gamified intervention? ☐ Yes ☐ No Which instrument? ☐ Intrinsic Motivation Inventory (IMI) (Ryan, 1982) ☐ Other _____	[1] [0]
Game Design Elements	
18) Game Design Elements (Components) select one or more:	
☐ Achievements ☐ Avatars ☐ Badges/Awards ☐ Timed activities ☐ Collections ☐ Teams (collaborative) ☐ Adaptivity/ Personalization ☐ Content ☐ Unlocking ☐ Gifting ☐ Leaderboards ☐ Quest/Missions/ Modules ☐ Competition ☐ Collaboration ☐ Levels ☐ Points/Experiences ☐ Virtual Goods ☐ Narrative/ Story telling ☐ Feedback ☐ Game fiction Other: _____	

☐	
19) Use of Feedback: ☐ Yes ☐ No Which type of feedback, according to Willert (2021) ☐ Formative ☐ Summative ☐ Immediate ☐ Self-regulation ☐ Scaffolding ☐ Social or Peer ☐ Other _____ _____ In which circumstances? _____ _____ _____	[1] [0]
20) In your research, are you going to consider evaluating the impact of single or multiple game elements, and the interaction between them with specific statistical analyses? ☐ Yes ☐ No Which element/s you will inspect? 1) _____ _____ 2) _____ _____ 3) _____ _____	[1] [0]

21) In your research, are you considering inspecting the interactions between different elements of gamification (e.g. game element/s, feedback/s, player's personality, learning types) with specific statistical analyses? ☐ Yes ☐ No Which? 1) _____ 2) _____ 3) _____	[1] [0]
Game Design	
22) Are you considering game design principles in your study? ☐ Yes ☐ No	[1] [0]
Learning Outcomes	
23) What specific learning outcome could be enhanced using the gamified system? ☐ Cognitive ☐ Motivational/Affective ☐ Behavioral ☐ Students learning ☐ Creativity ☐ Other: _____	
24) What we know today, divided for learning outcome Behavioral: • A general small to medium effect of gamification (1; 2) Intervention length: ○ Intervention less than 1 hour (3) ○ Intervention between 2-16 weeks (2) ○ Intervention between 1-2 years (- 1) Population Target: ○ Adults (3) ○ K-12 students (3) Gamification elements: ○ Non-linear navigation (3) ○ Game fiction (2) ○ Competition-Collaboration (2)	

- Adaptivity / Personalization (-1)
- Narrative / Story telling (-1)

Motivational/Affective:

- A general small to medium effect of gamification (1; 2)

  Intervention length:
  - Intervention less than 6 months (2)
  - Intervention less than 1 day (-1)

  Population target:
  - Higher/undergraduate (2)
  - K-12 students (3)

  Gamification elements:
  - Leaderboards (2)
  - Competition-Collaboration (2)

Cognitive:

- A general medium effect of gamification (2)

  Intervention length:
  - Intervention less than 1 day (2)
  - Intervention less than 1 months (2)
  - Intervention less than 6 months (2)

  Population target:
  - School (3)
  - Higher/undergraduate (2)

  Gamification elements:
  - Inconsistent results (0)

Students learning:

- A general medium effect of gamification (2; 3)

  Intervention length:
  - Intervention less than 1 week (2)
  - Intervention between 1-3 months (3)

  Course target:
  - Technology based courses (2)
  - Non-technology based courses (2)

  Population target:
  - Undergraduate students (2)

  Class size (0)

  Publication years (0)

  Gamification elements:

○ Responsive feedback (2) ○ Collaboration (2) ○ Quests/Missions/Modules (2) ○ Badges + Leaderboards + Points (2)	
Total points:	/20

Table 2 The Gamification Checklist Protocol with Likert' scale values (in brackets). Values in brackets represent a four-point likert scale. Values equals to -1 indicate a negative impact on learning or in methodological rigor. Values of 0 a neutral impact on learning or in the methodological rigor, values of 1 a low positive impact, values of 2 a medium positive impact, and values of 3 a high positive impact. These values if related to a learning aspect investigated in the meta-analyses mimic the estimated effect size according to Cohen (1992). The right-hand column features a point-based scoring system, which researchers and practitioners can use to complete the checklist prior to conducting their research or study. The total score attained could serve as a measure of the quality and methodological rigor of the proposed research. Higher total scores indicate higher-quality research, while lower scores correspond to research of lower quality.