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Impacts of Badges and Leaderboards on Academic Performance: A Meta-Analysis*

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As technological changes continue to accelerate every day, meeting the needs of a shifting educational landscape requires leaving an exclusively "in-person" education behind. Gamified learning environments should be carefully designed in light of conflicting studies to suit students' needs. The purpose of this meta-analysis is to draw conclusive results regarding the application of the most commonly used game elements in education, i.e., badges and leaderboards, through a comprehensive analysis of their impact on academic performance in online learning. Review Manager (RevMan 5.4) was used to analyze eligible studies selected from Emerald, SAGE, ERIC, EBSCO, and ProQuest between January 2011 and January 2022. Analyzing 37 studies found that using leaderboards and badges in online education enhanced academic performance when compared to traditional learning without gamification (*SMD* = 0.39). The badge-only intervention showed a larger effect size (*SMD* = 0.33) than the leaderboard-only intervention (*SMD* = 0.27). Badges and leaderboards together exhibited a larger effect size (*SMD* = 0.48) than individual game elements (*SMD* = 0.40). The impact of the game elements on academic performance was greater in the humanities (*SMD* = 0.51) than in STEM fields (*SMD* = 0.32) and was greater for K-12 students (*SMD* = 0.63) than for college students (*SMD* = 0.31). This study contributes to a timely discussion of the use of badges and leaderboards in COVID-19 online learning trends and provides relevant data for designing integrations of online education and gamification models.

Keywords : Gamification, Badge, Leaderboard, Meta-analysis, Online learning

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Introduction

During this time of dramatic shifts in the COVID-19 pandemic and technological advancements, online platforms have become a more common medium of communication, interaction, as well as learning than traditional face-to-face medium. One issue often reported by both teachers and students is the inability to focus on learning content due to limitations in social interactions and immediate feedback online. This lack of mental fortitude or resilience is obviously not inherent to online content platforms, as youth and adults alike commonly report spending extended hours on games and videos (Mcgonigal, 2011).

Although games can become a distraction and even lead to addiction when overused (Andrade et al., 2016), well-researched integration of gamification into learning tools and methods could enable educators to reach a population that has otherwise proven difficult to reach, especially a solution to a humanitarian crisis in which large numbers of students cannot attend school and where classes are overcrowded and teachers are overburdened (Kim & Lee, 2015; Oliveira et al., 2021).

Even before COVID-19, there was an educational gap depending on socioeconomic background (Von Stumm, 2017). However, as school classes have been switched to online learning, it is known that the educational gap has deepened depending on parents' income (Goudeau et al., 2021). Nevertheless, gamified teaching methods open doors for isolated students, especially for guiding students in underserved communities (Heinert et al., 2021; Watson-Huggins, 2018). This new normal of online learning in the post-COVID-19 era presents not only challenges but opportunities as well. Incorporating well-suited game elements and guidance into online platforms has the potential to be excellent and engaging learning environments (Saleem et al., 2021).

Gamification helps students seek and achieve a positive experience in their learning, encouraging them to be self-motivated and challenge themselves, which leads to increased enjoyment of learning (Bernik et al., 2015; Nieto-Escamez &

Roldán-Tapia, 2021). As online learning becomes more prevalent (Sailer & Homner, 2020), it is important to properly motivate students who participate in this gamified online learning (Zichermann & Cunningham, 2011). Gamification aims to accelerate students' academic performance by adding motivating game elements to the learning content. To measure the impacts of badges and leaderboards on academic performance, this study examined the effect sizes of exams, tests, and quizzes, and assignments presented in previous studies.

This study differs from previous meta-analyses in looking at ways to tackle the complexity of gamification by focusing on and comparing the difference between students' respective use of badges and leaderboards and their combined use for academic purposes. Although gamification has received a lot of attention. There is no general consensus on the effectiveness of badges and leaderboards. On the one hand, other studies have suggested that badges and leaderboards may hinder learning by making students feel disconnected from the subject matter and putting too much emphasis on gamifying outcomes (Baydas & Cicek, 2019; Hung, 2017). For example, according to a recent meta-analysis of gamification (Huang et al., 2020), studies that did not use leaderboards had a statistically significant greater impact than those that did.

On the other hand, the most popular game features in education are badges and leaderboards, as they can be simply converted to a digital format while retaining their functionality (Homer et al., 2018; Werbach et al., 2012). Other game elements include avatars, quests, modules or missions, and storytelling narratives (Ritzhaupt et al., 2021). Compared to badges and leaderboards, these other features are less applicable to online learning environments because they require a degree of flexibility that makes them less adaptive to predefined curricula with numerous students.

A well-functioning online learning environment requires accountability, which is why badges and leaderboards are effective visual indicators of whether students are actually learning (Hamari, 2017; Sailer et al., 2017). Educators and students can use these capabilities to track development, performance, and growth over time, and this

data tracking enables educators to provide more personalized support to students (Hakulinen et al., 2015). Leaderboards and badges can also serve as extrinsic motivators by rewarding and recognizing learners' achievements (Fanfarelli & Mcdaniel, 2019).

Previous research has presented an analysis of gamification models of multiple game elements, presenting the combined synergies (Dichev & Dicheva, 2017; Kusuma et al., 2018; Mekler et al., 2017). Gamification contains a myriad of elements, including mechanics, dynamics, and aesthetics, and the gamification model may change when different elements are manipulated (Kim & Lee, 2015; Kusuma et al., 2018). Therefore, considering parts of gamification rather than the entire gamification system will create a more tailored and effective gamification model (Strmečki et al., 2015).

High-quality elements are important to gamification models. Despite the popularity in education, research on the effectiveness of leaderboards and badges has yielded inconsistent results (Balci, 2022). Analyzing each element through a bottom-up approach will lead to a deeper understanding of which elements are significant in the gamification model.

Research questions

1. Do badges and leaderboards contribute to students' overall academic performance?

2. Are there any differences between the separate use of badges and leaderboards on the effect of academic performance?

3. Is a combination of both badges and leaderboards more effective for academic performance than utilizing either one individually?

4. Are there any differences on the effect of academic performance based on moderating variables (i.e., subject area and education level)?

In this study, the term "badge" is defined as a symbol or indicator of one's skills

and accomplishments and can be used as a form of public recognition. A traditional badge system was frequently used in Boy Scouts in the United States, in which a series of tasks must be accomplished in order to be awarded a merit badge (Kim & Castelli, 2021). Similarly, the badging system in many online learning programs gamifies the learning experience by displaying students' achievements and status visually to motivate and bring about feelings of accomplishment and competition (Hakulinen & Auvinen, 2014).

The term "leaderboard" is described as a representation of a student's standing in respect to their class or group in a desired subject or activity, acting as a catalyst for competition between students. Depending on how they perform, their rank positions can move up or down a ladder, providing students with a "status" and opportunities to progress in a public way (Teasley, 2017, p. 379). Many online games employ leaderboard systems to motivate players to keep playing and gain a sense of accomplishment as they move up the rankings.

Literature Review

Theoretical background: Gamification and learning motivation

Gamification is widely used for marketing and sales purposes in different fields. For instance, points for merchandise purchase and a level system in card membership add social and cultural interest to motivate consumers' continuous use. Gamification gained popularity in online education for its easy adoption from traditional classrooms to digital formats by simply adding game features to existing content (Huang et al., 2020). The goal of gamification is to present learning outcomes in a game-like system to motivate students (Zichermann & Cunningham, 2011).

Motivation comes in many different forms of wants and needs; in Maslow's hierarchical pyramid, the needs are structured from physiological to social and

emotional needs, which need to be met for self-actualization to ultimately be achieved (Maslow, 1954). According to Maslow, before students are able to achieve their learning goals, they must first have a safe learning environment and gain belonging and esteem. By gamifying the learning process through recognition and rewards for their achievements, students develop a sense of belonging and self-esteem and are more likely to be motivated to achieve their goals. By addressing social and emotional needs, students begin to achieve motivation for self-actualized learning, the highest tier of Maslow's pyramid. Ultimately, gamification can play a significant role in helping students achieve their full potential (Greitzer, 2007).

Goal-setting theory shows that it is critical to constantly set new goals in order to motivate oneself. The theory posits that individuals are motivated to achieve specific, challenging goals and that this motivation increases as the goal becomes more difficult (Bai et al., 2021). Thus, successful attainment of status goals in badges and leaderboards puts this theory into practice. By setting small, achievable goals and providing badges for reaching those goals, students can stay motivated and engaged in their work. Leaderboards also provide a tangible way to measure goals and see how one's performance compares to others.

Furthermore, social comparison theory posits that individuals evaluate their own abilities and aspirations relative to others in order to measure their own status. This self-evaluation is often motivated by a desire to be acknowledged by others (Festinger, 1954). When students see that their efforts are being acknowledged by others, they are more likely to be motivated to do well (Furdu et al., 2017). In addition, gamification can also provide opportunities for students to compare their own progress to that of their classmates. By seeing how they stack up against their peers, students can be motivated to improve their own performance (Auvien et al., 2015).

By tracking their progress and sharing their accomplishments, students want to be recognized for their efforts. While this motivation may lead to some short-term success, it is often not sustainable in the long run. Social comparison can be a

destructive force, leading to feelings of inadequacy and insecurity. Those who focus on the gamifying aspect may find it difficult to stay motivated once the initial novelty wears off. It is important for students to find intrinsic sources of inspiration if they want to achieve lasting success (Özdener, 2018).

Using leaderboards and badges for online learning in schools

The digital age has dramatically changed the landscape of education. Students are no longer confined to a traditional classroom environment and now have access to a wealth of online resources. In order to better take advantage of this shift, educators are examining how educational practices can be better adapted to meet the needs of digital learners (Ghasia et al., 2019). One area that has seen significant growth is gamification (Sailer & Homner, 2020).

Traditional settings typically have a sticker chart on the wall to reward classroom behavior and learning. At the end of the month, the student with the most stickers is rewarded with a "student of the month" badge. Students' names are put next to achievements as visual representations to motivate learners. From the sticker chart, this has been extended by digital alternatives to online platforms such as Classdojo, which can customize badges to meet the needs of any classroom, providing a more interactive experience (Homer et al., 2018).

The most common type of leaderboard is a simple table showing how many people have completed a specific task, such as the number of people who have finished reading a book. In an online learning environment, leaderboards can be utilized in a variety of ways to show the simultaneous progress of many different groups of students (Landers et al., 2015). Using a leaderboard can be a great way for students to see how their performance is compared to others across various subjects or even within an entire classroom. This can also be used as a motivator for students who are having trouble staying motivated or working on certain tasks. These types of leaderboards can work well with online learning environments as they allow

educators to see students' performance easily and quickly while they are completing their classwork (Christy & Fox, 2014).

Consequently, these gamified reward formats are most commonly used in both digital and non-digital educational settings (Werbach et al., 2012). However, there have been conflicting results from previous research regarding the efficacy of badges and leaderboards (Hamari et al., 2014; Seaborn & Fels, 2015). Other studies have suggested that these extrinsic motivators actually inhibit learning (Dominguez et al., 2013; Hanus & Fox, 2015).

Benefits. Badges and leaderboards in online learning environments can work similarly as they both show visual representations of students' achievement and progress. These game features are easily implemented from a token reward system in a traditional classroom to a digital format while enhancing their effectiveness (Homer et al., 2018). These game elements serve not only as explicit goals towards next level or benchmark and endorsements to reinforce learning but also visibly tract their progress as formative assessments (Mah, 2016; McDaniel & Fanfarelli, 2015).

Drawbacks. Despite the positive impact of badges and leaderboards, educators also need to be cautious of the negative impact on learning when experiencing failure amidst challenges, evaluations, and competition (Hung, 2017). For example, if leaderboards are used in a way that promotes competition among students, this can lead to feelings of stress and anxiety. Alternatively, if badges are given out too freely, they may lose their value and become ineffective, which can lead to a lack of connection to the content (Baydas & Cicek, 2019).

Moderating factors

Combination or individual usage of the game elements. Over the past decade, gamification research in the context of online learning has become increasingly

popular (Sailer & Homner, 2020). In most studies, several game elements are used. Combining game elements intensifies their effectiveness by complementing each other while providing more and different feedback (Kusuma et al., 2018). Evaluating badges and leaderboards individually is important to understand how each element contributes to the overall performance. Considering a specific game element with a greater impact can avoid any additional implementation costs (Mazarakis & Bräuer, 2022).

Subject areas. The use of badges and leaderboards for different subject areas and student groups should be taken into consideration when planning a gamification strategy. The scope of the application can be expanded by navigating mediating factors to validate previous findings. Research has shown that STEM subjects with algorithmic, repetitive, and predictable outcomes produce higher academic performance than non-STEM subjects (Kapsalis et al., 2020; Lam et al., 2018).

Educational level. A recent meta-analysis suggests that college students benefit more from gamification than K–12 students (Kim & Castelli, 2021). In addition, higher education appears to be most frequently involved in gamification research, according to a recent meta-analysis (Ritzhaupt et al, 2021). In the study of the Swedish comprehensive school, students' interest and intrinsic motivation in various subjects lessened as they advanced their grade level, prominently in science and math subjects, and their intrinsic motivation stabilized after 8th grade due to their developmental changes, where a difference was no longer seen in results between the 8th and 9th grade classes (Hedelin & Sjöberg, 1989). Development of age-appropriate educational programs increases student participation and knowledge transfer (Jensen et al., 2013).

Methods

Frame the question

"Participant-Intervention-Comparator-Outcomes" (PICO) model was used to frame a focused research question in the meta-analysis (Schardt et al., 2007): "Participant" included students enrolled in formal online education settings, "Intervention" involved gamification elements of badges or leaderboards; "Comparator" was a control group in online learning in which no gamification element was provided; "Outcome" included academic performance such as test scores or participation grade; and "study design" included experimental studies.

Data collection

The main databases for the literature search are as follows: Emerald, SAGE, ERIC, EBSCO, and ProQuest. Search terms were used in a combination of badges and leaderboards-related terms, such as "medals," "badges," "leaderboards," "ranking," and performance-related terms, such as "learning," "achievement," and "grade."

Quantitative experimental design research articles published from January 2011 to January 2022 were selected. The research criteria included in the meta-analysis were as follows: (a) the intervention was delivered online or through a digital medium; (b) gamified interventions included badges or leaderboards, or both; and (c) experimental designs with traditional learning control groups; within-subject designs with pre- and post-tests were excluded.

As a result of the first step, an initial database search using subject keywords and related references yielded a total of 506 studies, and 69 of them were duplicates. The subsequent analysis did not include duplicates.

In the second step, after screening by title and abstract, another 18 studies were found to be irrelevant such as studies of virtual reality game design or marketing, and those studies were excluded from the further analysis.

Table 1
Inclusion and exclusion criteria

Criterion	Included	Excluded
Language	English	Other languages
Publication Type	Peer-reviewed journals or conference papers, dissertations	Magazine articles, reports
Type of study	Experimental design	Systematic literature review, qualitative study
Participants	Students attending educational institutions (Primary, Secondary, and College)	Neither enrolled or defined in a formal educational institution (Community-based and non-credit programs)
Outcome	Academic performance	Outcomes other than academic performance (motivation, engagement)

In the third step, another batch of 79 qualitative studies and literature studies that did not suggest an effect size were excluded. In addition, 57 quantitative studies with correlation coefficients that did not provide the mean difference between experimental and control groups and the number of cases were also excluded.

The fourth step excluded 72 gamification studies that did not use badges or leaderboards. 52 studies with participants in gifted or special education, non-formal educational settings and not currently enrolled were also excluded.

Following the selection processes described above, 33 papers met all the criteria for inclusion in this study, which included 26 peer-reviewed journals, 4 conference papers, and 3 dissertations. Of the 33 papers, 2 compared the separate effects of badges and leaderboards, respectively, and 1 compared badges, leaderboards only, and both, for a total of 37 studies reviewed.

Statistical analysis

In this study, Cochrane's open software, Review Manager (Revman 5.4), was used for effect size calculation and subgroup analysis. The effect size summarizes the quantitative size of each study weight to integrate the standardized mean values of the intervention effect. According to Cohen's (2013) criteria, the calculated effect size was interpreted as "small" if it was less than .10, "medium" if it was about .30, and "large" if it was .50 or more. A 95% confidence interval was applied.

To estimate the effect size of a continuous outcome variable, the mean difference (*MD*) is used when data from included studies are reported on the same scale. Since the scales used in individual studies are diverse, the standardized mean difference (*SMD*) was used by dividing the effect size by the standard deviation and calculated using Hedges' adjusted *g*. According to standard practice, heterogeneity levels are interpreted as small if the value is 0–25%, medium at 50%, and high at 75% or more Considering that the research backgrounds of individual studies, sample size, and scales are diverse, a random effects model was applied for the analysis.

Due to the high degree of heterogeneity between studies, subgroup analyses were used to understand uncertain complexities and to explore deeper explanations and greater nuances. The chi-square test is sensitive to the number of studies and the sample size gets smaller in subgroup analyses, leading to insignificant heterogeneity. Therefore, it is recommended to consider the statistical significance level to be 0.10 rather than 0.05 (Higgins et al., 2003).

Results

Overall effects of badges and leaderboards

In Table 2, the total effect size analyzed by the random effect model for a total of

36 studies was found to be .39 with a confidence interval of 0.26–0.53; 0 was not included in the 95% confidence interval, thus the effect size was found to be statistically significant. Applying Cohen's (2013) interpretation criteria, the overall effect size was small. This validates the positive impact of badges and leaderboards on academic performance. As the heterogeneity, I^2 is 75% or more, it is interpreted that the ratio of inter-study variance is very large (Higgins et al., 2003). Further subgroup analyses were required to explain the high heterogeneity of 81%.

Table 2
Overall effect size of badges and leaderboards

n	ES	95% CI		Heterogeneity	
		Lower	Upper	I^2	*p*
2823	0.39	0.26	0.53	81	<.001

Leaderboards vs. Badges

To test the differences between the separate use of badges and leaderboards on the effect of academic performance, 9 leaderboard-only and 14 badges-only studies were examined for subgroup analysis in Table 3. In the leaderboards-only subgroup, a total of 9 studies measured 0.27 of *SMD* and 0.05 to 0.53 of 95% CL. This suggests a small effectiveness of the leaderboard group compared to the traditional learning control group. I^2 showed a high heterogeneity of 74%.

Table 3
Effect sizes of leaderboards vs. badges respectively

Outcome Variables	*n*	ES	95% CI		Heterogeneity	
			Lower	Upper	I^2	*p*
Leaderboards-only	511	0.27	0.01	0.53	74	<.001
Badges-only	1386	0.33	0.04	0.62	90	<.001

In the badges only subgroup, a total of 14 studies measured 0.33 of *SMD* and 0.04 to 0.62 in 95% CL. Again, this suggests a small effect size of the badge group when compared with the traditional learning group. I^2 showed a high heterogeneity of 90%.

Applying leaderboards and badges individually in online learning had a positive effect on academic performance compared to the traditional learning; all effect sizes were found to be statistically significant. The badges-only group had a 6% higher effect size than the leaderboards-only group.

Single game element vs. combined game elements

The effect sizes for two subgroups are presented in Table 4. The first subgroup uses only one game element, either badges or leaderboards alone, while the second subgroup uses both badges and leaderboards. In the first subgroup, a total of 23 studies measured the effect size of a single game element (badge or leaderboard), showing a standardized mean difference of 0.40 and a 95% confidence interval of 0.14 to 0.66. This suggests a small effect size of the single game element group when compared with the traditional learning group ($Z = 2.97$, $p < .001$). I^2 showed a high heterogeneity of 89%.

According to the second subgroup, 14 studies found that badges and leaderboards combined had a standardized mean difference of 0.48, with a 95% confidence interval of 0.36 to 0.60. This suggests a small effect size of the combined game element group when comparing with the traditional learning group ($Z = 8.04$, $p < .01$). I^2 showed a low heterogeneity of 22%. The combined game element group had a larger effect size than the more heterogeneous single game element group.

Table 4
Effect sizes of single game element vs. combined game element

Outcome Variables	*n*	ES	95% CI		Heterogeneity	
			Lower	Upper	I^2	*p*
Single game element	1455	0.40	0.14	0.66	89	<.001
Combined game element	868	0.48	0.36	0.60	22	<.001

Moderating variables

In this study, the moderating effects of subject area and education level variables were examined. In Table 5, the moderating effect of subject areas was examined by subgroup analysis of STEM and the humanities. A total of 22 studies measured the overall effect size of STEM subjects, while a total of 15 studies were in the humanities. An effect size of g = 0.32 (0.19 to 0.46 in 95% CL) was obtained in the STEM (Z = 2.95, p < .01) with a moderate heterogeneity of 46%. On the other hand, an effect size of g = 0.51 (0.24 to 0.78 in 95% CL) was obtained in the humanities (Z = 2.93, p < .01) with a high heterogeneity of 91%. According to the findings, the subject area difference in which gamification has been used has a significant moderating effect on academic performance (Z = 3.86, p < .05). Accordingly, a 27% higher effect size was observed in STEM than the humanities subjects.

Table 5

Effect sizes by moderator variables

Moderating Variables		n	ES	95% CI		Heterogeneity	
				Lower	Upper	I^2	p
Subject Area	STEM	1637	0.32	0.19	0.46	61	<.001
	Humanities	1186	0.51	0.24	0.78	89	<.001
Education Level	K-12	546	0.63	0.21	0.41	93	<.001
	College	2277	0.31	0.14	1.12	53	<.001

In addition, the moderating effects of educational level were examined for primary and secondary education in comparison to college education. A total of 9 studies were included in the K-12 groups, including 6 primary education studies and 3 secondary education studies, with a standardized mean difference of 0.63 and a 95% confidence interval of 0.21 to 0.41 (Z = 2.53, p = .01) with a high level of heterogeneity of 93%. The gamified college group included a total of 28 studies, showing a standardized mean difference of 0.31 and a 95% confidence interval of

0.14 to 1.12 (Z = 5.95, p < .001). I^2 showed a moderate heterogeneity of 53%.

The educational level of students in gamified online learning had a significant moderating effect on academic performance - the college group (Z = 5.95) was nearly twice as high as that of the K-12 groups (Z = 2.53).

Publication bias

The results of the meta-analysis were validated using a funnel plot, which displays the intervention effect size on the horizontal axis and the standard error on the vertical axis (Zhou et al., 2013). The figure shows large sample studies at the top and small sample studies at the bottom. As shown in Figure 1, there was no publication bias as most of the data were distributed symmetrically around the mean effect size (*SMD*=0.4), with few outliers.

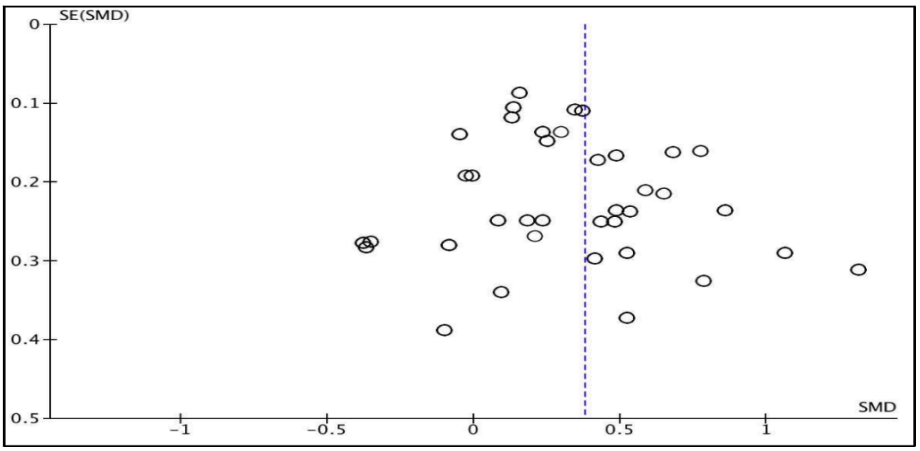

Figure 1. Funnel plot of effect size data.

Discussion and Conclusion

In preparation for the post-COVID-19 era, we are rapidly accelerating into the

digital age; online courses and platforms are rising to the center of academic learning. As screen time increases, motivation and engagement are critical for academic learning (Chans & Portuguez Castro, 2021). By examining prior research on how leaderboards and badges impact academic performance, this study was able to draw conclusions for effective gamification in formal online learning. This research adds to a deeper knowledge of how these game elements function individually as well as together in order to build more successful gamified learning experiences for various participant groups and subject areas.

First, this meta-analysis finds that badges and leaderboards improve academic performance. This result is in line with previous studies (Mah, 2016; Xu et al., 2021), which demonstrated that using leaderboards and badges to gamify learning has advantages (Huang et al., 2020). When students are engaged emotionally, cognitive engagement occurs and makes learning connected (Plass et al., 2020). This proposition justifies the rationale for implementing game elements into online learning models that influence motivation and ultimately impact students' academic performance outcomes (Landers, 2015).

Second, badges-only intervention studies showed a larger effect size than the leaderboards-only intervention studies. This result contradicts a previous systematic review (Looyestyn et al., 2017) that claimed that leaderboards are more practical and relate to daily life with social comparison, while badges lack motivational value. However, it is important to note that leaderboards can also lead to negative social comparisons if used inappropriately in line with the social comparison theory. For example, if the score displayed on the leaderboard is too high, it might discourage students from continuing to compete. Struggling students further lose confidence in their abilities by comparison (Crabtree & Rutland, 2001). For those less accustomed to competition and academic pressures, students experience frustration when losing. This might lead to negative self-evaluation of lower-performing students and can negatively affect their academic performance (Hanus & Fox, 2015).

The use of leaderboards in an online gamified environment can be a great

motivating factor but is not a reliable educational tool for measuring objective academic performance because the standards are relative to competitors. Instead of promoting deep learning, some researchers argue that it encourages students to focus on surface goals, such as earning more badges or getting high score level (Baydas & Cicek, 2019; Hung, 2017). Students should understand that one's success is not about winning and scoring better than others. Rather, it is important for students to realize that they have a unique learning journey of their own and not focus on getting ahead or falling behind in the gamified elements (Margolis & Mccabe, 2006).

Third, the combined effects of badges and leaderboards show a higher effect size than a single game element group. This is consistent with earlier research showing that using only one or two gamified components, like points or badges, has a lessening or even negative impact on student motivation and reinforces gamification models with multiple elements (Kusma et al., 2018). Utilizing both badges and leaderboards should be taken into consideration when creating a more immersive and engaging experience for students (Manzano-León et al., 2021).

As opposed to earlier studies that suggested STEM subjects were associated with improved academic performance, the humanities subjects such as social studies, foreign language learning, and argumentative writing, which involve applying and coming up with new ideas, had a bigger impact on academic performance than STEM subjects (Kapsalis et al., 2020; Lam et al., 2018).

As a result of the selection process in the last 10 years from 2011 to 2022, 24 out of 37 studies in total targeted college students, accounting for 65% of the total study subjects. The data supports that the number of college students taking at least one online course increased from 10% to 30% between 1999 and 2015 (Allen & Seaman, 2017). Despite the hypothesized association that gamified online programs are concentrated toward targeting college students, the primary & secondary group was significantly higher for impacts on academic performance compared with the college group.

As a result of these findings, we may be able to better understand the

characteristics of digital natives who are accustomed to a fast pace and technology-infused learning environment (Sarkar et al., 2017). Digital natives have a different learning style from previous generations of students due to their upbringing in a continuously changing environment with new online media content (Kivunja, 2014). Tailoring the design and execution of gamification for the intended participants can improve an online learning environment (Pursell, 2009).

Limitations

The current study has limitations which may warrant further study of the subject. Although the results of meta-analysis support the effectiveness of badges and leaderboards on academic performance, the reliability of this data is impacted by a relatively small sample size. Our results suggest small effect sizes, implying that additional large-scale standardized online programs are needed to fully comprehend the impact of each game feature in determining its cross-sectional validity. Determining whether badges and leaderboards have the capacity to sustain motivation over the long term is also beyond the scope of this study as it is not longitudinal in nature.

Cultural differences and underlying social and psychological components may have an impact on the study's findings and limit its applicability to a larger population. For instance, a comparison of Korean and Austrian students' perceptions of gamification reveals cultural variations such as collectivism of social enjoyment and individualistic tendency for cognitive pleasure (Kim & Kim, 2018). Thus, further analysis of contributing factors is needed to validate the findings. In such an intervention process, it should be appropriately designed to provide an environment for self-motivated participation and to avoid negative perceptions or anxiety about social comparison (Crabtree & Rutland, 2001). This understanding will be helpful for students who are struggling academically and under stress. Ultimately, what works for one student may not work for another, so it is important to tailor motivation

strategies to the needs of each individual.

A set of eligibility criteria restricted the methodological choices, such as descriptive and qualitative studies. For this meta-analysis, continuous data was used with experimental designs, excluding interviews, literature reviews, and studies with no control group or lack of statistical data. This may result in research lacking specific details about personal reflections and individual feedback. The investigation of the motivational impact of employing badges and leaderboards is beyond the scope of this study.

Implications

Further research is needed to determine the impact of learning content. Learning content is a key contributor to academic performance. Gamification generates game-like features in part for non-game structures. On the other hand, serious games take a different form entirely. As an example, game-based learning is designed for educational purposes as a whole, from start to finish. Additional study is needed to examine the varying effects of gamification and game-based learning, which have different compositions (Deterding et al., 2011).

Social comparison theory suggests that game elements do not affect performance when learning content is too challenging, whether it is in a face-to-face or online setting (Ding, 2019; Jagušt et al., 2018). Frustration occurs when students think the challenge is too difficult, and their skills don't match. Their academic stress affects their performance and motivation (Crabtree & Rutland, 2001).

When used effectively, badges and leaderboards can be powerful tools for motivating students to achieve their goals. Badges and leaderboards can provide motivation for any type of behavior an educator is attempting to influence. In line with the goal-setting theory, they help students visualize their learning progress and set next goals for future learning. This sets expectations for a goal-oriented mindset and serves to vouch for students' acquired skills and readiness for the next level badge

(Hamari, 2017; Sailer et al., 2017). Students can move strategically along their learning goals, gradually increasing the level (Fanfarelli & Mcdaniel, 2019).

Findings from the current study could help educators utilize the most popular game elements, badges, and leaderboards to enhance students' academic performance as a successful intervention technique. This study sheds light on the impact of badges and leaderboards in relation to gamification design, subject area, and educational level, suggesting that students respond differently to varied motivations. A one-size-fits-all approach is therefore inefficient, and it is essential to consider factors impacting students who engage in gamified learning and properly motivate students with the growth of online learning platforms (Zichermann & Cunningham, 2011). Creating engaging and effective gamified learning environments can prepare students and teachers for future educational changes to accommodate technological advances (Jensen et al., 2013).

References

Note. References marked with an asterisk (*) indicate the studies included in the meta-analysis.

*Ahmad, A., Zeshan, F., Khan, M., Marriam, R., Ali, A., & Samreen, A. (2020). The impact of gamification on learning outcomes of computer science majors. *ACM Transactions on Computing Education, 20*(2), 1-25.

Andrade, F. R., Mizoguchi, R., & Isotani, S. (2016). The bright and dark sides of gamification. *Intelligent Tutoring Systems*, *9864,* 176-186.

*Auvinen, T., Hakulinen, L., & Malmi, L. (2015). Increasing students' awareness of their behavior in online learning environments with visualizations and achievement badges. *IEEE Transactions on Learning Technologies*, *8*(3), 261-273.

*Balci, S., Secaur, J. M., & Morris, B. J. (2022). Comparing the effectiveness of badges and leaderboards on academic performance and motivation of students in fully versus partially gamified online physics classes. *Education and Information Technologies, 27*(6), 8669-8704.

Barata, G., Gama, S., Jorge, J., & Gonçalves, D. (2014). Identifying student types in a gamified learning experience. *International Journal of Game-Based Learning, 4*(4), 19-36.

Baydas, O., & Cicek, M. (2019). The examination of the gamification process in undergraduate education: A scale development study. *Technology, Pedagogy and Education, 28*(3), 269-285.

*Bernik, A., Bubaš, G., & Radošević, D. (2015). A pilot study of the influence of gamification on the effectiveness of an e-Learning course. *26th Central European Conference on Information and Intelligent Systems (CECIIS 2015)*, 73-79.

*Çakıroğlu, Ü., & Güler, M. (2021). Enhancing statistical literacy skills through real life activities enriched with gamification elements: An experimental study. *E-Learning and Digital Media*, *18*(5), 441-459.

Chans, G. M., & Portuguez Castro, M. (2021). Gamification as a strategy to increase

motivation and engagement in higher education chemistry students. *Computers, 10*(10), 132.

Chen, C.-C., Huang, C., Gribbins, M., & Swan, K. (2018). Gamify online courses with tools built into your learning management system (LMS) to enhance self-determined and active learning. *Online Learning*, *22*(3), 41-54.

*Christy, K. R., & Fox, J. (2014). Leaderboards in a virtual classroom: A test of stereotype threat and social comparison explanations for women's math performance. *Computers & Education*, *78*, 66-77.

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Taylor and Francis.

Crabtree, J., & Rutland, A. (2001). Self-evaluation and social comparison amongst adolescents with learning difficulties. *Journal of Community* & *Applied Social Psychology, 11*(5), 347-359.

*Denny, P., McDonald, F., Empson, R., Kelly, P., & Petersen, A. (2018). Empirical support for a causal relationship between gamification and learning outcomes. *Proceedings of the 2018 CHI conference on human factors in computing systems*, 1-13.

Dichev, C., & Dicheva, D. (2017). Gamifying education: What is known, what is believed and what remains uncertain: A critical review. *International Journal of Educational Technology in Higher Education*, *14*(1), 9.

*Ding, L. (2019). Applying gamifications to asynchronous online discussions: A mixed methods study. *Computers in Human Behavior*, *91*(February), 1-11.

*Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J.-J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers* & *Education*, *63*, 380-392.

Fanfarelli, J. R., & McDaniel, R. (2019). *Designing effective digital badges: Applications for learning*. Routledge.

Festinger, L. (1954). A theory of social comparison processes. *Human Relations*, *7*(2), 117-140.

Furdu, I., Tomozei, C., & Kose, U. (2017). Pros and cons gamification and gaming in classroom. *Broad Research in Artificial Intelligence and Neuroscience, 8*(2), 56-62.

Ghasia, M., Machumu, H., & de Smet, E. (2019). Micro-credentials in higher education institutions: An exploratory study of its place in Tanzania. *The International Journal of Education and Development Using Information and Communication Technology*, *15*(1), 219-230.

*Goosby, C. L. (2020). *Using Digital Badges to Impact First Grade Math Achievement: A Quasi-experimental Study of Digital Badges and the North Carolina Early Numeracy Skills Indicators* (Publication No. 28318393) [doctoral dissertation, Northcentral University] PQDT Open.

Goudeau, S., Sanrey, C., Stanczak, A., Manstead, A., & Darnon, C. (2021). Why lockdown and distance learning during the COVID-19 pandemic are likely to increase the social class achievement gap. *Nature Human Behaviour*, *5*(10), 1273-1281.

Greitzer, F. L., Kuchar, O. A., & Huston, K. (2007). Cognitive science implications for enhancing training effectiveness in a serious gaming context. *Journal on Educational Resources in Computing, 7*(3), 2.

*Gündüz, A. Y., & Akkoyunlu, B. (2020). Effectiveness of gamification in flipped learning. *SAGE Open*, *10*(4), 215824402097983.

Hakulinen, L., & Auvinen, T. (2014). The effect of gamification on students with different achievement goal orientations. *Proceedings of the 2014 international conference on teaching and learning in computing and engineering, Kuching, Malaysia*, 9-16.

Hakulinen, L., Auvinen, T., & Korhonen, A. (2015). The effect of achievement badges on students' behavior: An empirical study in a university- level computer science course. *International Journal of Emerging Technologies in Learning, 10*(1), 18-30.

Hamari, J. (2017). Do badges increase user activity? A field experiment on the effects of gamification. *Computers in Human Behavior, 71*, 469-478.

Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers and Education, 80*, 152-

161.

Heinert, S. W., Quasim, N., Ollmann, E., Socarras, M., & Suarez, N. (2021). Engaging youth through digital badges to promote health in underserved communities. *Health promotion practice*, *22*(5), 631-637.

*Foon, H. K., & Ki, L. C. (2019). Using digital badges and leader-boards in primary school math lessons: Beneficial or merely *new wine in old bottles?*. In W. Ma, W. Chan & C. Cheng (Eds.), *Shaping the future of education, communication and technology. Educational communications and technology yearbook* (pp. 71-90). Springer.

Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *British Medical Journal*, *327*(7414), 557-560.

Homer, R., Hew, K. F., & Tan, C. Y. (2018). Comparing digital badges-and-points with classroom token systems: Effects on elementary school ESL students' classroom behavior and English learning. *Journal of Educational Technology & Society*, *21*(1), 137-151.

*Huang, B., & Hew, K. F. (2015). Do points, badges and leaderboard increase learning and activity: A quasi-experiment on the effects of gamification. *Proceedings of the 23rd International Conference on Computers in Education, China,* 275-280.

Huang, R., Ritzhaupt, A. D., Sommer, M., Zhu, J., Stephen, A., Valle, N., Hampton, J., & Li, J. (2020). The impact of gamification in educational settings on student learning outcomes: A meta-analysis. *Educational Technology Research and Development*, *68*(4), 1875-1901.

*Jagušt, T., Botički, I., & So, H.-J. (2018). Examining competitive, collaborative and adaptive gamification in young learners' math learning. *Computers & Education*, *125*, 444-457.

Jensen, J. C., Lee, E. A., & Seshia, S. A. (2013). Virtualizing cyber-physical systems: Bringing CPS to online education. *Proceedings of the First Workshop on CPS Education (CPS-Ed),* 1-5.

*Kapsalis, G. D., Galani, A., & Tzafea, O. (2020). Kahoot! as a formative assessment

tool in foreign language learning: A case study in greek as an L2. *Theory and Practice in Language Studies*, *10*(11), 1343-1350.

Kivunja, C. (2014). Theoretical perspectives of how digital natives learn. *International Journal of Higher Education*, *3*(1), 94-109.

Kim, J., & Castelli, D. M. (2021). Effects of gamification on behavioral change in education: A meta-analysis. *International Journal of Environmental Research and Public Health*, *18*(7), 3550.

Kim, J. T., & Lee, W. H. (2015). Dynamical model for gamification of learning (DMGL). *Multimedia Tools and Applications*, *74*(19), 8483-8493.

Kim, J., & Kim, S. (2018). A comparative study on the differences in cultural attributes of gamification between Korea and Austria. *Journal of the Korea Industrial Information Systems Research, 23*(1), 109-122.

Kusuma, G. P., Wigati, E. K., Utomo, Y., & Suryapranata, L. K. (2018). Analysis of gamification models in education using MDA framework. *Procedia Computer Science*, *135*, 385-392.

Kyewski, E., & Krämer, N. C. (2018). To gamify or not to gamify? An experimental field study of the influence of badges on motivation, activity, and performance in an online learning course. *Computers* & *Education, 118*(1), 25-37.

*Lam, Y. W., Hew, K. F., & Chiu, K. F. (2018). Improving argumentative writing: Effects of a blended learning approach and gamification. *Language learning* & *technology*, *22*(1), 97-118.

*Landers, R. N., Bauer, K. N., & Callan, R. C. (2017). Gamification of task performance with leaderboards: A goal setting experiment. *Computers in Human Behavior, 71,* 508-515.

*Legaki, N. Z., Xi, N., Hamari, J., Karpouzis, K., & Assimakopoulos, V. (2020). The effect of challenge-based gamification on learning: An experiment in the context of statistics education. *International Journal of Human-Computer Studies*, *144*, 102496.

Looyestyn, J., Kernot, J., Boshoff, K., Ryan, J., Edney, S., & Maher, C. (2017). Does

gamification increase engagement with online programs? A systematic review. *PloS One*, *12*(3), e0173403.

Mah, D. K. (2016). Learning analytics and digital badges: Potential impact on student retention in higher education. *Technology, Knowledge and Learning*, *21*(3), 285-305.

Manzano-León, A., Camacho-Lazarraga, P., Guerrero, M. A., Guerrero-Puerta, L., Aguilar-Parra, J. M., Trigueros, R., & Alias, A. (2021). Between level up and game over: A systematic literature review of gamification in education. *Sustainability*, *13*(4), 2247.

Margolis, H., & Mccabe, P. P. (2006). Improving self-efficacy and motivation: What to do, what to say. *Intervention in School and Clinic, 41*(4), 218-227.

Maslow, A. H. (1954). *Motivation and Personality*. Harper & Row Publishers.

Mazarakis, A., & Bräuer, P. (2022). Gamification is working, but which one exactly? Results from an experiment with four game design elements. *International Journal of Human–Computer Interaction*, 1-16.

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

Mekler, E. D., Brühlmann, F., Tuch, A. N., & Opwis, K. (2017). Towards understanding the effects of individual gamification elements on intrinsic motivation and performance. *Computers in Human Behavior, 71,* 525-534.

*Morris, B. J., Dragovich, C., Todaro, R., Balci, S., & Dalton, E. (2019). Comparing badges and learning goals in low- and high-stakes learning contexts. *Journal of Computing in Higher Education*, *31*(3), 573-603.

*Newby, T. J., & Cheng, Z. (2020). Instructional digital badges: Effective learning tools. *Educational Technology Research and Development*, *68*(3), 1053-1067.

Nieto-Escamez, F. A., & Roldán-Tapia, M. D. (2021). Gamification as online teaching strategy during COVID-19: A mini-review. *Frontiers in Psychology, 12,* 648552.

*Ongoro, C. A., & Mwangoka, J. W. (2019). Effects of digital games on enhancing language learning in Tanzanian preschools. *Knowledge Management & E-Learning*,

11(3), 325-344.

Özdener, N. (2018). Gamification for enhancing Web 2.0 based educational activities: The case of pre-service grade school teachers using educational Wiki pages. *Telematics and Informatics, 35*(3), 564-578.

Poondej, C., & Lerdpornkulrat, T. (2019). Gamification in e-learning: A Moodle implementation and its effect on student engagement and performance. *Interactive Technology and Smart Education, 17*(1), 56-66.

Pursell, D. P. (2009). Adapting to student learning styles: Engaging students with cell phone technology in organic chemistry instruction. *Journal of Chemical Education, 86*(10), 1219.

Ritzhaupt, A. D., Huang, R., Sommer, M., Zhu, J., Stephen, A., Valle, N., Hampton, J., & Li, J. (2021). A meta-analysis on the influence of gamification in formal educational settings on affective and behavioral outcomes. *Educational Technology Research and Development*, *69*(5), 2493-2522.

Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human* Behavior, 69, 371-380.

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. *Educational Psychology Review*, *32*(1), 77-112.

*Sailer, M., & Sailer, M. (2021). Gamification of inclass activities in flipped classroom lectures. *British Journal of Educational Technology*, *52*(1), 75-90.

Saleem, A. N., Noori, N. M., & Ozdamli, F. (2021). Gamification applications in E-learning: A literature review. *Technology, Knowledge and Learning, 27,* 1-21.

Sarkar, N., Ford, W., & Manzo, C. (2017). Engaging digital natives through social learning. *Systemics, Cybernetics and Informatics*, *15*(2), 1-4.

Schardt, C., Adams, M. B., Owens, T., Keitz, S., & Fontelo, P. (2007). Utilization of the PICO framework to improve searching PubMed for clinical questions. *BMC medical informatics and decision making*, *7*(1), 1-6.

Seaborn, K., & Fels, D. I. (2015). Gamification in theory and action: A survey.

International Journal of Human-Computer Studies, *74*, 14-31.

*Silpasuwanchai, C., Ma, X., Shigemasu, H., & Ren, X. (2016). Developing a comprehensive engagement framework of gamification for reflective learning. *Proceedings of the 2016 ACM Conference on Designing Interactive Systems*, 459-472.

*Stetson-Tiligadas, S. M. (2016). *The impact of digital achievement badges on undergraduate learner motivation* (Publication No. 10037460) [Doctoral dissertation, Capella University] PQDT Open.

Strmečki, D., Bernik, A., & Radošević, D. (2015). Gamification in E-learning: Introducing gamified design elements into E-learning Systems. *Journal of Computer Science*, *11*(12), 1108-1117.

*Tahir, F., Mitrovic, A., & Sotardi, V. (2022). Investigating the causal relationships between badges and learning outcomes in SQL-Tutor. *Research and Practice in Technology Enhanced Learning*, *17*(1), 7.

Teasley, S. D. (2017). Student facing dashboards: One size fits all?. *Technology, Knowledge and Learning*, *22*(3), 377-384.

*Tsay, C. H.-H., Kofinas, A., & Luo, J. (2018). Enhancing student learning experience with technology-mediated gamification: An empirical study. *Computers & Education*, *121*, 1–17.

*Turan, Z., Avinc, Z., Kara, K., & Goktas, Y. (2016). Gamification and education: Achievements, cognitive loads, and views of students. *International journal of emerging technologies in learning*, *11*(7).

*Uanhoro, J., & Young, S. S. (2022). Investigation of the effect of badges in the online homework system for undergraduate general physics course. *Education Sciences*, *12*(3), 217.

*Ugur-Erdogmus, F., & Çakır, R. (2022). Effect of gamified mobile applications and the role of player types on the achievement of students. *Journal of Educational Computing Research*, *60*(4), 1063-1080.

*Uz Bilgin, C., & Gul, A. (2019). Investigating the effectiveness of gamification on group cohesion, attitude, and academic achievement in collaborative learning

environments. *TechTrends*, *64*(1), 124-136.

Von Stumm, S. (2017). Socioeconomic status amplifies the achievement gap throughout compulsory education independent of intelligence. *Intelligence*, *60*, 57-62.

*Watson-Huggins, J. (2018). *An experimental study on the effects of a gamified software intervention in mathematics achievement among sixth grade students* (Publication No. 13820081) [Doctoral dissertation, Nova Southeastern University]. PQDT Open.

Werbach, K., & Hunter, D. (2012). *For the win: How game thinking can revolutionize your business*. Wharton School Press.

Xu, J., Lio, A., Dhaliwal, H., Andrei, S., Balakrishnan, S., Nagani, U., & Samadder, S. (2021). Psychological interventions of virtual gamification within academic intrinsic motivation: A systematic review. *Journal of Affective Disorders*, *293*, 444-465.

*Zainuddin, Z. (2018). Students' learning performance and perceived motivation in gamified flipped-class instruction. *Computers* & *Education*, *126*, 75–88.

Zhou, T., Hu, Z., Zhou, Z., Guo, X., & Sha, J. (2013). Genome-wide analysis of human hotspot intersected genes highlights the roles of meiotic recombination in evolution and disease. *BMC Genomics*, *14*(1).

*Zimmerling, E., Höllig, C. E., Sandner, P. G., & Welpe, I. M. (2019). Exploring the influence of common game elements on ideation output and motivation. *Journal of Business Research*, *94*, 302-312.

Zichermann, G., & Cunningham, C. (2011). *Gamification by design: Implementing game mechanics in web and mobile apps*. O'Reilly Media, Inc.

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