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Effects of Gamification Strategies on Learning Mathematics: A Meta-Analysis

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Abstract

Mathematics learning often challenges students, as maintaining motivation, engagement, and achievement can be difficult. Gamification has emerged as a promising strategy to enhance learning experiences and participation. This study examined the overall effects of gamification on mathematics learning across educational levels, identified the most effective strategies, and assessed the reliability of findings. From an initial screening of 3,000 studies, 16 were selected following the PRISMA process and assessed for quality using the CASP checklist. Descriptive and inferential statistics analyzed the prevalence and effectiveness of gamification strategies, while subgroup analyses compared K-12, secondary, and higher education levels. Heterogeneity, stability, and publication bias were

assessed using standard methods, and all results were generated in JASP for transparency and reproducibility. The findings indicated a moderate-to-large overall effect of gamification on mathematics learning ($M = 0.444$, 95% CI [0.387–0.502]), with consistent positive outcomes across educational levels. Game-Based Learning (42.9%) and Game Elements (28.6%) were most effective, while other gamified strategies supported personalized learning. Then, minimal publication bias confirmed the reliability of these results. Thus, these results suggest gamification is an effective instructional approach, enhancing cognitive, affective, and behavioral outcomes, and educators are encouraged to integrate gamified elements in diverse mathematics learning contexts.

Keywords: Effects, Gamifications Strategies, Mathematics Education, Quantitative Study, Learning Mathematics

Introduction

The strategies teachers employ to teach mathematics impact students' understanding. Consequently, many students view mathematics as a difficult subject, and so those student encounter difficulties when they come to learn mathematics (Akçay *et al.*, 2021; Krosbergen *et al.*, 2022). Therefore, learning difficulties in mathematics are common among those students who don't get adequate support or when the teaching strategies doesn't suit their learning needs. In fact, according to the Trends in International Mathematics and Science Study (TIMSS), only 19% of Filipino Grade 4 students reached the "low" benchmark in mathematics, highlighting the urgent need for more effective teaching strategies (Mullis *et al.*, 2020). Similarly, Programme for International Student Assessment (PISA) in 2022 showed Filipino students scored an average of 355, far below the Economic Co-operation and Development (OECD) average of 472, with over 85% of 15-year-olds failing to meet the minimum proficiency level (OECD, 2023).

Moreover, with the growing utilization of digital tools in education, especially following the shift caused by the COVID-19 pandemic, educators have explored innovative ways to enhance engagement and achievement in mathematics. One such innovation is the use of gamification strategies where it is the application of game elements (e.g., points, badges, levels, leaderboards, and other competitive games) in non-game learning environments to motivate students and improve learning outcomes. And these gamification strategies are widely used not only in the Philippines but also globally (Duterte, 2024).

From a theoretical viewpoint, gamification in mathematics draws on Self-Determination Theory, which emphasizes autonomy, competence, and relatedness, and Flow Theory, which highlights engagement through clear goals, feedback, and balanced challenges (Luarn *et al.*, 2023; Peng *et al.*, 2023; Oliveira *et al.*, 2022). These theories help explain why gamification can boost not only participation but also persistence in solving complex mathematical problems. Building on these theoretical foundations, practical applications of gamification in mathematics make learning more engaging by combining fun, challenge,

and reward. It is integrated into online or classroom settings, for instances, strategies like scoring systems, missions, and competitions boost motivation, participation, and performance, while encouraging persistence and a sense of accomplishment (Daliva, 2024).

Meanwhile, some studies, globally, have observed whether gamification is effective for learning mathematics. Many findings suggest positive effects on mathematics learning by increasing engagement, motivation, problem-solving, and attitudes toward math (Setiawan *et al.*, 2022; Díaz *et al.*, 2023; Puspitasari *et al.*, 2023; Tan, 2023). In Philippine contexts, there was a systematic and experimental reviews of gamification in Filipino mathematics education found that gamification tends to improve engagement and academic performance in math (Nob *et al.*, 2024; Loquias *et al.*, 2023). In addition, recent studies locally (within Cebu) show that gamification significantly improves mathematics learning outcomes. Derasin *et al.*, (2023) found that digital gamification enhanced students' achievement at Bantayan National High School compared to traditional teaching. Likewise, Canlas *et al.*, (2024) reported improved interest and understanding among Grade 10 learners in Bogo City through gamified activities, while Sulpico *et al.* (2024) showed that both digital and non-digital game-based learning in Cebu City raised post-test scores, participation, and enjoyment. As these findings, integrating gamification strategies presents a promising pathway toward revitalizing mathematics education and addressing persistent challenges in student motivation and achievement.

While many global, national, and local studies report positive effects of gamification in mathematics, findings remain inconsistent. Meta-analyses show varied results: Li *et al.*, (2023) found large positive effects but noted differences by student type, subject, and setting. Outcomes also depend on factors like prior knowledge, self-regulation, and technology access (Han *et al.*, 2021). In the Philippines, studies such as Lim (2021) at Eastern Samar State University and local works in Cebu (Derasin *et al.*, 2023; Canlas *et al.*, 2024) show benefits in performance and motivation, though challenges like competition stress, limited technology, and diverse learner needs persist. Since the outcomes of individual studies differ, a meta-analysis is helpful. These findings point to a critical gap: there is no clear consensus on the overall effectiveness of gamification in mathematics education, nor on the conditions under which it works best. Addressing this gap requires synthesizing existing research to identify patterns, moderating variables, and best practices.

Research Objectives

This meta-analysis aims to synthesize existing research on the effects of gamification strategies on learning mathematics. Particularly, the study seeks to determine the overall effects of gamification strategies on students' mathematics learning across different educational level. Furthermore, it intends to identify which common types of gamification strategies are most effective in supporting mathematics learning. Lastly, the meta-analysis examines the potential for publication bias in the body of current literature and evaluates the consistency and reliability of findings across research.

Review of Related Literature

This literature review synthesizes empirical along with review-level research on gamification strategies or game-based approaches in mathematics education because it stresses studies and meta-analyses that speak directly to (1) effects of gamification strategies on mathematics learning across educational levels, (2) what common types of gamification strategies are most effective based on the collated studies, and (3) issues of publication bias and consistency.

Furthermore, the review draws mainly from the references that are provided (2020–2025) for supporting the stated objectives. The review considers meta-analyses, experimental reviews, and systematic research globally outside the Philippines, nationally within the Philippines, and locally within Cebu so that conclusions support the meta-analytic gap.

1. The Overall Effects of Gamification Strategies on Students' Mathematics Learning Across Different Educational Level

Gamification, which employs game design elements in a learning environment (for instance points, badges, rewards, challenges or leaderboards), is also an extensively studied strategy to enhance the motivation and engagement of students with mathematics. It found evidences of overall effects of gamification strategies on mathematics learning at different levels (from primary school to higher education). To address the first objective, this review synthesizes these findings based on a range of studies (with related results), categorizes them according to how gamification aids learning, and considers what affects its effectiveness.

From a theoretical perspective, gamification works in mathematics learning because of Self-Determination Theory (SDT) and Flow Theory. SDT explains that students are more motivated when their needs for control, competence, and connection with others are met. Gamified features like challenges, badges, and leaderboards give students a sense of control, achievement, and teamwork, which keeps them engaged (Luarn *et al.*, 2023; Peng *et al.*, 2023). Flow Theory shows that deep learning happens when students have clear goals, quick feedback, and a good balance between challenge and skill, which well-designed games provide (Oliveira *et al.*, 2022). Together, these ideas show why gamification can increase participation, persistence, and problem-solving in math at all levels.

1.1 Effects of Gamification Strategies on Motivation and Engagements

Globally, a large number of studies confirm that gamification greatly increases students' motivation and engagement in math learning. For example, Fadda *et al.* (2021), Vankúš (2021), Baah *et al.* (2023), and Li *et al.* (2024) reported that digital game elements make students feel more interested and willing to participate. Similarly, Khaldi *et al.* (2023), Kovácsné (2021), Maryana *et al.* (2024), and Ratinho *et al.* (2023) find that gamification makes learning math more enjoyable and encourages students to stay focused.

Furthermore, several studies stress specific gamification features as main motivators which are immediate feedback,

social competition, and collaboration (Lampropoulos *et al.*, 2024; Meng *et al.*, 2024; Sousa-Vieira *et al.*, 2023; Zaric *et al.*, 2020; Cigdem *et al.*, 2024; Tan *et al.*, 2023). Then, leaderboards, badges, and points are repeatedly mentioned as effective rewards that sustain motivation (Zaric *et al.*, 2020; Cigdem *et al.*, 2024; Vergara *et al.*, 2024; Malahito *et al.*, 2020).

According to Puspitasari *et al.* (2023), Nair *et al.* (2021), Hsu *et al.* (2023), López *et al.* (2021), Gui *et al.* (2023), and Saxena *et al.* (2021), younger and adult students alike respond positively to gamified learning environments, with detailing increased engagement in classrooms ranging from elementary schools to secondary to universities.

Nationally, there was a meta-analysis study conducted by Llanes (2025) in Laguna, Philippines that analyzed various gamified instruction strategies in mathematics education. Their findings revealed that gamified instruction provided students with positive experiences, enabling them to learn mathematics in an engaging manner without significant effort. This approach not only improved student motivation but also fostered meaningful learning experiences, highlighting the effectiveness of gamification in enhancing mathematics education.

Locally, the researchers found out that the study of Dela Cruz *et al.* (2021) observed Filipino secondary students in Cebu City, Philippines responses to gamified math quizzes and found higher and improved motivation and participation. Similarly, Reyes *et al.* (2023) also conducted a study in Cebu City, Philippines showing that gamified learning platforms like Quizizz and Kahoot! increased students' active involvement and enjoyment during math lessons.

1.2 Gamification Enhances Academic Achievement in Mathematics

According to Zhang *et al.* (2022), Karamert *et al.* (2021), Malvasi *et al.* (2022), Yanurito *et al.* (2023), Fuentes *et al.* (2023), and Abu *et al.* (2023), researches consistently show that gamification leads to higher math achievement that demonstrate improved test scores and problem-solving skills in primary and secondary education.

In higher education, Yoo *et al.* (2023), Ortiz-Rojas *et al.* (2025), Khaldi *et al.* (2023), and Kovácsné (2021) observed positive results, though somewhat smaller, gains. This may be because college-level mathematics is more challenging and self-directed.

On the other hand, as noted by Rodrigues *et al.* (2022) nationally, and connect it to the studies of these researchers globally from Li *et al.* (2023), and Zeng *et al.* (2024) highlight the “novelty effect,” where students initially show big gains but lose interest if the gamification remains unchanged. They recommend dynamic, adaptive designs to maintain achievement over time.

Other meta-analyses, including Wang *et al.* (2022), Li *et al.* (2024), and Gui *et al.* (2023), reinforce that sustainable gamification design is critical for continued academic improvements.

Locally, as stated by Mendoza *et al.* (2022) in their research at Cebu Normal University (CNU) found that integrating game-based learning strategies significantly improved college students' math achievement in Algebra and Statistics courses. Their findings from the local studies align with broader observations globally from Abu *et al.* (2023) and Yanurito *et al.* (2023) who show that gamified interventions

help secondary students grasp challenging concepts like geometry.

1.3 Positive Cognitive and Emotional Effects

As reported by Hui *et al.* (2023); Özhan *et al.* (2020); Jaftha *et al.* (2021), show that gamification lessens math anxiety and increases students' confidence level. Locally, Santos *et al.* (2023) reported similar results where students in Cebu, Philippines expressed decreased stress and greater willingness to participate in math class following gamified interventions and strategies.

Nevertheless, in the view of Al-Hafdi *et al.* (2024), Saxena *et al.* (2021), and Ren *et al.* (2024) underline how gamification increases determination and enjoyment, essential for sustained math learning.

In addition to these studies, Malabayabas *et al.* (2024) conducted a study in the Philippines that examined the effectiveness of gamified applications in enhancing students' academic performance in mathematics. The study found that the integration of game-based activities in educational settings offered numerous benefits, including increased student engagement and improved academic performance. These advantages underscore the potential of gamification to positively impact students' cognitive and emotional experiences in learning mathematics.

These emotional benefits have been echoed in Filipino classrooms, in particular, in Cebu City, which showed Filipino learners' positive emotional engagement when lessons included game elements (Villamor *et al.*, 2023).

1.4 Key Gamification Components for Success

As documented by Zaric *et al.* (2020); Cigdem *et al.* (2024); Vergara *et al.* (2024), show that leaderboards, badges, and points motivate students but adaptive difficulty is important to keep students challenged without frustration (Zhang *et al.*, 2024; Li *et al.*, 2023).

Additionally, social learning and instant feedback improve engagement and understanding (Sousa-Vieira *et al.*, 2023; Meng *et al.*, 2024; Tan *et al.*, 2023). However, Pradhan *et al.* (2024) stated that over-competition among students can cause stress.

Then, adding storytelling and real-world situations helps connect math to everyday life (Lampropoulos *et al.*, 2024; Hao *et al.*, 2024). For example, Filipino teachers in the Philippines, including those in Cebu, emphasize cultural relevance and language accessibility as additional factors that increase the effectiveness of gamification (Garcia *et al.*, 2022; Malabayabas *et al.* 2024; Reyes *et al.*, 2023).

1.5 Other Effects of Gamification Strategies

Globally, gamification fosters enthusiasm and the development of fundamental math skills (Panskyi *et al.*, 2021; Alotaibi, 2024). Nationally, Malabayabas *et al.* (2024) saw Filipino students reacting positively to math games with Filipino cultural themes that helped put abstract ideas into situation.

Relate to this, gains in motivation and learning outcomes are reported in international studies (Natividad *et al.*, 2022; Yanurito *et al.*, 2023; Fuentes *et al.*, 2023). Through official technology integration programs, the Department of Education (DepEd) encourages schools across the country, including those in Cebu, to implement gamified digital tools for math instruction in secondary students.

Thus, research shows more modest but meaningful effects on engagement and motivation (Khaldi *et al.*, 2023; Kovácsné, 2021; Ortiz-Rojas *et al.*, 2025). Locally, higher education schools like Cebu Normal University have begun implementing gamification in STEM courses with early positive feedback (Mendoza *et al.*, 2022).

Even though gamification works well, there are challenges. Rodrigues *et al.* (2022) and Li *et al.* (2023) warn that if the games don't change or get harder, students lose interest after a while. Teachers need proper training and support to use gamification well, which López *et al.* (2021), Lampropoulos *et al.* (2024), and Khaldi *et al.* (2023) all point out as a big hurdle.

Also, Klock *et al.* (2024) remind us that gamification should be fair and inclusive, so it helps all students, not just those with easy access to technology or certain skills.

Overall, it has been commonly shown that gamification using game elements like leaderboards, badges, points and other stratified game elements within math instruction increases students' academic success while motivating them at all educational levels from elementary school to college. Math activities that are gamified increase interest along with focus and also enjoyment. Studies conducted both domestically as well as internationally, including within the Philippines, indicate they also improve test scores along with problem-solving abilities. Immediate feedback is given social competition occurs people work as a team content is culturally relevant as well as these are important to succeed however originality must be preserved overly competitive environments must be avoided and inclusivity must be guaranteed. Emotional advantages including less math anxiety and more confidence further support long-term learning. For students to stay motivated and benefit educationally for a long time, designing games adaptively and training teachers are necessary to implement with success.

2. Common Types of Gamification Strategies Are Most Effective in Supporting Mathematics Learning

Gamification in mathematics teaching uses many game elements designed to motivate and engage students, making learning more interactive and fun. To address the second objective, this section reviews the common types of gamification strategies that shown consistent effectiveness in supporting math learning.

2.1 Points, Badges, and Leaderboards

One of the most common and effective strategies involves giving points, badges, and using leaderboards to recognize students' achievement and progress. These reward systems encourage healthy competition and give students clear goals to reach, which increases motivation and persistence (Fadda *et al.*, 2021; Lampropoulos *et al.*, 2024). For example, leaderboards help students monitor their performance compared to their other classmates, fostering engagement and a sense of accomplishment (Cigdem *et al.*, 2024; Zeng *et al.*, 2024).

In the Philippines, Duterte (2024) conducted a study examining the impact of educational gamification on student engagement, motivation, and academic performance in higher education. The study utilized a mixed-methods approach with 133 undergraduate students from three private universities in Manila. Gamification elements, including points, badges, leaderboards, and collaborative

challenges, were integrated into an online learning environment. The results revealed statistically significant improvements in academic performance and motivation following the gamification intervention. Qualitative data highlighted students' positive perceptions of the gamified learning environment, with increased engagement and enjoyment reported.

Locally, Dela Cruz *et al.* (2021) found that gamified quizzes using point systems boosted motivation among Filipino secondary students, showing how such strategies effectively encourage continuous participation.

These findings also support some theories such as flow theory explains that clearly defined goals and measurable progress keep students fully engaged, while SDT highlights that recognition through badges and points satisfies learners' needs for competence and relatedness, enhancing motivation and persistence.

2.2 Immediate Feedback and Progression

Providing immediate feedback through digital games or gamified platforms allows learners to understand mistakes quickly and improve their skills (Li *et al.*, 2024; Zhang *et al.*, 2022). This instant response supports better learning by guiding students step-by-step through math problems. Combined with progression mechanisms like levels or missions, this keeps students motivated to advance and tackle harder concepts (Puspitasari *et al.*, 2023; Malvasi *et al.*, 2022).

In the Philippines, Duterte (2024) conducted a study with 133 undergraduate students from three private universities in Manila, integrating gamified elements including immediate feedback, levels, and progression-based challenges. The study found that students' academic performance and motivation improved significantly. Qualitative data also indicated heightened engagement, enjoyment, and persistence in learning mathematics when feedback was immediate and progression was clearly defined.

In Cebu's primary classrooms, Garcia *et al.*, (2022) reported that progression through levels helped young learners stay engaged and develop confidence in math skills.

Additionally, according to Flow Theory, immediate feedback and clear progression maintain a balance between challenge and skill, keeping learners in a state of deep focus. SDT emphasizes that this structure supports autonomy and competence, encouraging learners to continue improving.

2.3 Collaborative and Competitive Games

Games that include both collaboration and competition among students promote social interaction and motivation. Cooperative gamification encourages peer learning and discussion, which improves understanding (Gezmen *et al.*, 2021; Jaftha *et al.*, 2021). Competitive games, on the other hand, stimulate effort and enthusiasm through friendly rivalry (Wang *et al.*, 2022; Pehlivan *et al.*, 2023).

Nationally, a study by Moldez *et al.* (2024) at the University of the Philippines Open University explored the integration of gamification elements such as badges, leaderboards, and progress bars into Massive Open Online Courses (MOOCs). The research found that these elements significantly enhanced student engagement, motivation, and course completion rates, highlighting the effectiveness of gamified strategies in higher education.

In higher education, Mendoza *et al.* (2022) documented how gamified algebra games at Cebu Normal University

enhanced both collaborative learning and individual achievement.

These findings also support theories such as flow theory highlights that challenging yet achievable tasks, combined with social interaction, maintain engagement. SDT suggests that collaborative and competitive elements meet learners' needs for relatedness and competence, motivating them to participate actively.

2.4 Quizzes and Mini-Games

Short quizzes and mini-games embedded in lessons serve as fun, low-stress ways to practice math skills repeatedly. Studies globally and locally have shown that gamified quizzes, especially those using platforms like Quizizz and Kahoot! increase engagement and improve recall (Reyes *et al.*, 2023; Yanurito *et al.*, 2023). These tools are flexible and easy to integrate into both physical and remote classrooms.

Recent studies in the Philippines outside Cebu have highlighted the effectiveness of gamification in enhancing students' mathematics learning. Alcoba (2023) demonstrated that the use of Quizizz, a digital game-based platform, significantly improved the numeracy skills of Grade 8 students at Louella Gotladera Alcoba National High School by increasing engagement and interactive practice. Similarly, a systematic review by Reyes *et al.* (2024) revealed that gamification strategies in tertiary mathematics education across the Philippines positively influenced student motivation, engagement, and academic performance. Moreover, Bayani *et al.* (2023) found that gamified learning interventions for Grade 5 learners at Mulondo Central Elementary School improved both mathematics achievement and positive attitudes toward the subject. These studies collectively underscore that gamified strategies, including quizzes, mini-games, and progression mechanisms, are effective in fostering motivation, engagement, and improved learning outcomes among Filipino students nationwide.

Interestingly, Santos *et al.* (2023) found that quiz-based gamification reduced math anxiety among Cebu students, contributing to a more positive attitude toward mathematics. These findings also support theories such as flow theory explains that short, challenging activities with immediate feedback sustain focus and engagement. SDT highlights that quizzes and mini-games enhance competence by allowing students to track progress and achieve mastery at their own pace.

2.5 Storytelling and Thematic Challenges

Some studies globally highlight the importance of embedding math problems within stories or thematic contexts, making the learning experience more meaningful and relevant (Natividad *et al.*, 2022; Fuentes *et al.*, 2023). This approach encourages deeper cognitive engagement and helps students connect abstract math concepts to real-life situations.

In the Philippines, a study by Duterte (2024) involving 133 undergraduate students from three private universities in Manila found that integrating gamification elements, including storytelling and collaborative challenges, into online learning environments significantly improved student engagement, motivation, and academic performance. Thematic analysis of qualitative data highlighted students' positive perceptions of the gamified learning environment, with increased engagement and enjoyment reported.

In Cebu, as cited by Villamor *et al.* (2023) observed that

Filipino students emotionally connected more with math lessons when gamification included storytelling elements, improving both motivation and retention.

These findings also support theories such as flow theory suggests that immersion in meaningful contexts maintains deep engagement. SDT indicates that relevance and personal connection support autonomy and relatedness, further motivating learners.

2.6 Customization and Adaptive Learning

Adaptive gamification tailors' challenges and feedback based on individual student performance and learning pace. This personalization addresses diverse needs, ensuring that all students are appropriately challenged without frustration (Rodrigues *et al.*, 2022; Li *et al.*, 2024). Customized experiences support self-regulated learning and promote mastery.

Nationally, a study by Dabingaya (2022) explored the effectiveness of AI-powered adaptive learning systems in mathematics education. The research indicated that personalized learning routes enabled by AI technologies led to increased student engagement and significant improvements in mathematical competency, emphasizing the potential of adaptive learning systems to enhance educational outcomes.

Supporting this, research from Lopez *et al.* (2024) highlighted infrastructure challenges in Cebu schools but emphasized the potential of adaptive gamified systems once proper resources are in place.

These findings also support theories such as flow theory explains that matching task difficulty to skill level maintains engagement and prevents boredom or frustration. SDT emphasizes that personalized challenges meet the needs for autonomy and competence, promoting sustained motivation and learning.

Overall, gamification strategies such as points, badges, leaderboards, immediate feedback, collaborative games, quizzes, storytelling, and adaptive learning enhance motivation, engagement, and achievement in mathematics. Flow Theory shows that clear goals, matched challenges, and immediate feedback create deep engagement, while Self-Determination Theory explains how these strategies fulfill psychological needs for autonomy, competence, and relatedness. Together, these theories support the effectiveness of gamification, making math learning both enjoyable and academically meaningful across educational levels. Building on these findings, the next section provides practical recommendations for educators on effectively implementing gamification strategies in mathematics classrooms.

3. Examining Publication Bias and Reliability of Findings

To fulfill the third objective, this section examines the potential publication bias and the consistency of findings in gamification strategies study. The meta-analyses among included studies in this research recognize that publication bias is possible, where studies that find positive effects of gamification are more likely to be published than those that show neutral or negative outcomes (Cheung *et al.*, 2021; Li *et al.*, 2024). Educators and policymakers can have their confidence in the overall effectiveness of gamification affected by this bias. How they see it can also feel this bias. However, many of the meta-analyses have applied strict

statistical methods in order to assess and adjust for such biases because that improves the reliability of conclusions (Zhang *et al.*, 2022; Zeng *et al.*, 2024). Well-designed gamification strategies typically improve motivation plus learning outcomes in mathematics due to the consistency across various educational settings, age groups, and study designs (Fadda *et al.*, 2021; Wang *et al.*, 2022).

Nonetheless, varied effects highlight how contextual factors such as student characteristics, instructional design, and technology access matter since educators must think over applying gamification (Han *et al.*, 2021; Rodrigues *et al.*, 2022).

Methodology

According to Borenstein *et al.* (2021), a meta-analysis is a statistical method that combines relevant results from multiple research studies to provide a more comprehensive and reliable conclusion about a specific topic. In the context of education, meta-analyses are useful because they help to simplify and explain diverse and inconsistent results found in preceding studies (Cheun *et al.*, 2021). In this study, the method was to analyze and synthesize existing relevant studies, in particular, those experimental researches, systematic reviews and studies, and meta-analyses studies, creating a stronger foundation for how gamification

strategies in mathematics education impact the way students engage in mathematical content. As a result, this type of analysis enhances better decisions by teachers, curriculum developers, and policymakers (Wang *et al.*, 2022).

Search Strategy

A scholarly electronic database search was conducted to find English-language studies related to the Effects of Gamification Strategies on Learning Mathematics, using the Harzing Publish or Perish Version 8 in 2021 software with access to three databases namely Google Scholar, Open Alex, and Crossref. Relevant studies to the Effects of Gamification Strategies on Learning Mathematics, published between 2020-2025, were collected and reviewed. The keywords applied in the three databases (Google Scholar, Open Alex, and Crossref) search via Harzing Publish or Perish Version 8 in 2021 software included: effects, gamifications strategies, mathematics education, quantitative study, learning mathematics. Aside from that, manual searching was also considered to find additional relevant studies within the local and national context. The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA 2020) flow diagram was used to systematically organize and document the selection process.

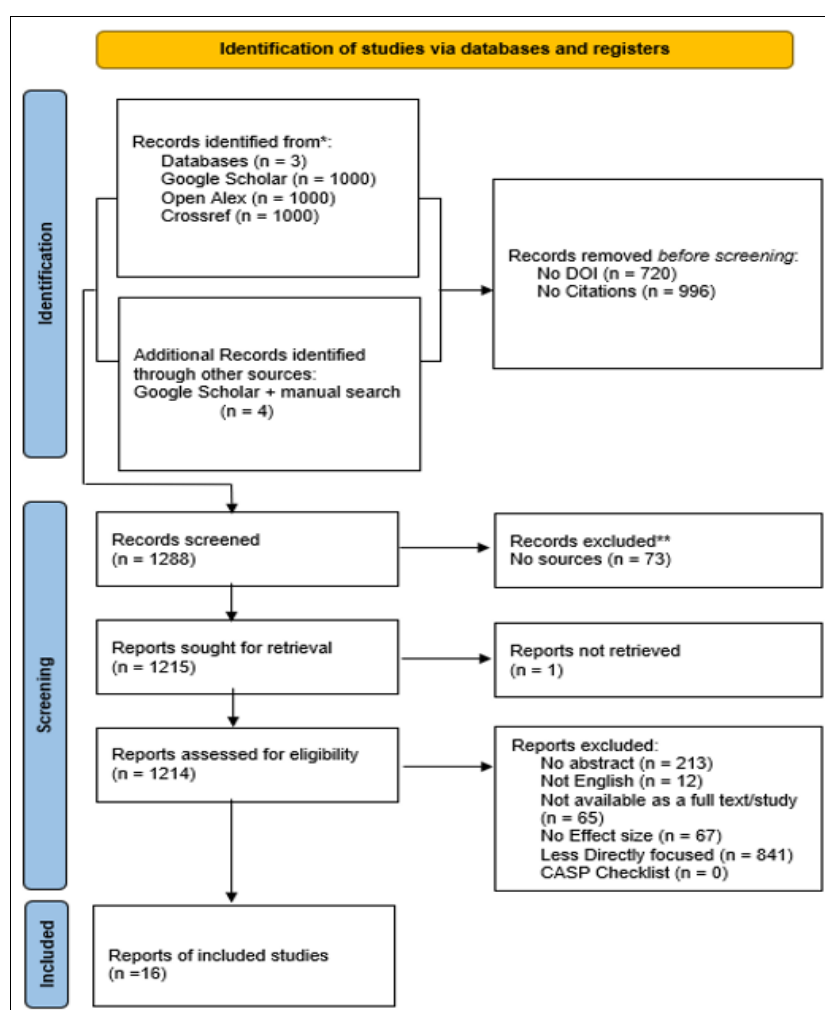


Fig 1: Screening process using the PRISMA 2020

The PRISMA 2020 diagram outlines the process of identifying, screening, and selecting studies for this meta-analysis on the effects of gamification strategies on learning mathematics. The initial database search across Google Scholar, OpenAlex, and Crossref yielded 3000 records, with an additional four studies identified manually. After removing 720 records lacking DOIs and 996 without citations, 1288 studies remained for screening. At this stage, 73 records were excluded due to inaccessible sources, leaving 1215 reports for retrieval. One report could not be obtained, and the remaining 1214 underwent full-text assessment.

During eligibility evaluation, 213 studies were excluded for having no abstract, 12 for being in languages other than English, 69 for lacking full text, 67 did not provide an effect size, and 841 were found to be less directly focused on the research topic. No exclusions were made using the Critical Appraisal Skills Programme (CASP) checklist since all the remaining studies passed the CASP criteria, with a minimum score of eight (8) out of ten (10) or 80%, which the researchers agreed to set as the acceptable threshold.

After applying these criteria, 16 studies were deemed eligible and were included in the meta-analysis. This rigorous and transparent selection process, guided by PRISMA 2020 standards (Page *et al.*, 2021), ensured that the final dataset was both relevant and methodologically sound. By focusing only on studies that met strict inclusion standards, the meta-analysis provides robust evidence and reliable conclusions regarding the role of gamification strategies in enhancing mathematics learning.

By integrating the PRISMA selection process with the CASP quality evaluation, the study ensures that the final dataset represents both comprehensive coverage and methodological rigor, supporting reliable conclusions and practical recommendations for educators.

to ensure that the studies selected for this meta-analysis on gamification strategies in mathematics were both relevant and of high quality. Studies were considered eligible for inclusion if they were peer-reviewed and provided sufficient and credible information to contribute to the synthesis. Only sources that were accessible, written in English, and available in full-text form were included. Furthermore, studies needed to present measurable outcomes, preferably in the form of effect sizes, to allow for quantitative analysis. Research that was directly focused on the scope of the study was prioritized to ensure alignment with the objectives of the review.

On the other hand, several categories of studies were excluded. Materials lacking essential bibliographic details, such as a DOI or proper citations, were not considered due to verification and traceability issues. Sources that did not provide abstracts, or those unavailable as full-text documents, were excluded since they offered insufficient information for critical evaluation. Similarly, non-English studies were excluded to maintain consistency and avoid misinterpretation of findings. Research that did not present effect sizes, or those with outcomes not aligned closely with the study's objectives, were also set aside. Finally, the Critical Appraisal Skills Programme (CASP) which evaluates research validity, relevance, and methodological rigor (Singh, 2022), ensured that only studies of adequate methodological quality were retained, with non-compliant sources being excluded at this stage.

By applying these inclusion and exclusion criteria, the study filtered an initial pool of 3000 records down to 16 high-quality studies that passed both the PRISMA screening process (Page *et al.*, 2021) and CASP quality appraisal. This process ensured that the final analysis was built upon credible, relevant, and methodologically sound evidence, strengthening the validity and reliability of the findings.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were carefully designed

Characteristics of the Included Studies

Study No.	Author/Year	Setting	No. of Studies	Effect Size	CI (95%)	Standard Error
1	Fadda <i>et al.</i> (2021)	K-12	20	0.27	[0.14, 0.41]	0.07
2	Zhang <i>et al.</i> (2021)	K-12, Higher Education	18	0.42	[0.28, 0.56]	0.07
3	Zhang <i>et al.</i> (2022)	K-12, Higher Education	27	0.36	[0.22, 0.50]	0.07
4	Zhang <i>et al.</i> (2024)	K-12, Higher Education	45	0.47	[0.30, 0.64]	0.09
5	Wang <i>et al.</i> (2022)	K-12, Higher Education	33	0.67	[0.52, 0.81]	0.08
6	Gui <i>et al.</i> (2023)	K-12, Higher Education	86	0.62	[0.50, 0.75]	0.06
7	Li, <i>et al.</i> (2023)	K-12, Higher Education	41	0.41	[0.29, 0.53]	0.06
8	Puspitasari <i>et al.</i> (2023)	K-12, Higher Education	8	0.52	[0.36, 0.68]	0.08
9	Alotaibi (2024)	Early Childhood	136	0.45	[0.31, 0.59]	0.07
10	Li <i>et al.</i> (2024)	K-12, Higher Education	35	0.33	[0.24, 0.42]	0.05
11	Zeng <i>et al.</i> (2024)	K-12, Higher Education	22	0.38	[0.32, 0.44]	0.03
12	Duterte (2024)	Higher Education	133	0.40	[0.18, 0.62]	0.11
13	Rosil <i>et al.</i> (2025)	Secondary	30	0.55	[0.31, 0.79]	0.12
14	Malabayabas <i>et al.</i> (2024)	Secondary	29	0.49	[0.33, 0.65]	0.08
15	Li <i>et al.</i> (2024)	K-12, Higher Education	35	0.33	[0.24, 0.42]	0.05
16	Sulpico <i>et al.</i> (2024)	Secondary	28	0.44	[0.20, 0.68]	0.12

Data Analysis

This meta-analysis combined effect sizes from primary studies to estimate the overall impact of gamification on mathematics learning across educational levels. For each study, we extracted or computed standardized mean differences using Hedges' g (positive values favored gamified instruction). Studies were weighted by inverse variance.

A random-effects model was used to pool effects, with between-study variance (τ^2) estimated via restricted maximum likelihood. We reported pooled effects with 95% confidence intervals, corresponding z -tests, and 95% prediction intervals to describe the dispersion of true effects in comparable future settings.

Pre-specified subgroup analyses examined educational level as a moderator. Due to sparse data in some categories, levels with fewer than two studies were not meta-analyzed individually, and, where appropriate, adjacent levels were combined. Differences between subgroups were tested using a mixed-effects model with subgroup as a categorical moderator, summarized by the omnibus Q_m statistic.

Statistical heterogeneity was assessed with Cochran's Q , τ^2 , I^2 , and H^2 . Influence diagnostics included casewise measures (standardized residuals, hat values, DFFITS, and Cook's distance) and leave-one-out analyses to evaluate the stability of pooled estimates. Profile likelihood plots were used to inspect the precision and plausibility range of τ^2 .

To identify the most common types of gamification strategies used in effective mathematics classes, the data were analyzed using both descriptive and inferential statistics. Descriptive statistics were employed through frequency counts and percentages to summarize how often each strategy appeared across the included studies. The identified strategies (e.g., Game Based Learning, Game Elements, Gaming Tools, Gamification Platforms, Adaptive Gamified Assessment) were coded and tallied to determine their prevalence. These results were presented in tabular form and complemented with a descriptive plot, which provided a clear visual representation of the distribution of strategies and highlighted the most dominant approaches in mathematics education.

In addition, a Multinomial Test was conducted to statistically examine whether the observed distribution of strategies significantly deviated from what would be expected under equal representation. This inferential analysis provided evidence of whether certain gamification strategies were used more frequently than others in mathematics education.

Finally, publication bias and reliability of findings were examined. Standard errors (SE) were calculated for each effect size to evaluate the precision of estimates, and these were categorized into levels of precision (very precise, precise, moderate, or low). In addition, forest plots and residual funnel plots were generated to visually inspect potential asymmetries in the distribution of effect sizes, which would indicate possible publication bias. All analyses

were conducted using JASP statistical software to ensure transparency and reproducibility.

Ethical Considerations

In this meta-analysis, all the data used come from studies that are already published so no new data were gathered, and the researchers did not interact with any respondents directly. Because of this, the responsibility for informed consent, respondent privacy, and ethical approvals (such as institutional review board clearance) lies with the researchers of the original studies (Page *et al.*, 2021).

To make sure that the researchers' analysis stands on solid ethical ground, the researchers included only studies that followed proper ethical procedures. This means studies that stated they obtained respondent consent or received appropriate review board approval were eligible (Haddaway *et al.*, 2022). Furthermore, the researchers also followed PRISMA guidelines to keep the process transparent and avoid bias in selecting studies (Page *et al.*, 2021).

In line with this, the researchers assessed the risk of publication bias when only studies with positive results get published by using tools like funnel plots and statistical tests. These steps help ensure that the conclusions are fair and not skewed by missing data or selective reporting (McGuinness & Higgins, 2021).

Additionally, to judge the strength of the evidence and consistency of findings across studies, the researchers applied the effect sizes and standard errors, then, used JASP application which evaluates factors like risk of bias, inconsistency, and publication bias in the body of evidence.

Finally, the researchers openly declared any potential conflicts of interest among the research team and took care not to misinterpret data. All methods and decisions were documented transparently so other researchers can check and reproduce the work that builds trust and strengthens credibility.

Results and Discussion

This section addresses the three primary objectives of the study: (1) presenting the overall effects of gamification strategies on mathematics learning across educational levels, (2) identifying the common types of gamification strategies that are most effective in supporting mathematics learning, and (3) examining potential publication bias and assessing the reliability of the findings. All statistical tables and figures were generated using the JASP statistical software application to ensure methodological transparency and reproducibility. By focusing on these objectives, the section highlights the comprehensive role of gamification in mathematics learning, moving beyond individual dimensions such as motivation, engagement, or achievement to provide a broader perspective on its overall impact.

1. Overall Effects of Gamification Strategies on Learning Mathematics

Table 1.1: Descriptive Statistics of Overall Effect Sizes and Standard Errors for Gamification Strategies on Mathematics Learning

	Overall Effect Size	Standard Error
Valid	16	16
Missing	0	0
Median	0.43	0.07
Mean	0.444	0.076
Std. Error of Mean	0.027	0.006
95% CI Mean Lower	0.387	0.062
95% CI Mean Upper	0.502	0.089
Std. Deviation	0.107	0.025
95% CI Std. Dev. Lower	0.079	0.018
95% CI Std. Dev. Upper	0.166	0.039
Coefficient of variation	0.242	0.331
MAD	0.065	0.01
MAD robust	0.096	0.015
IQR	0.123	0.022
Variance	0.012	6.262×10^{-4}
95% CI Variance Lower	0.006	3.417×10^{-4}
95% CI Variance Upper	0.028	0.002
Skewness	0.573	0.397
Std. Error of Skewness	0.564	0.564
Kurtosis	0.07	-0.022
Std. Error of Kurtosis	1.091	1.091
Shapiro-Wilk	0.971	0.94
P-value of Shapiro-Wilk	0.856	0.348
Range	0.4	0.09
Minimum	0.27	0.03
Maximum	0.67	0.12
25th percentile	0.375	0.06
50th percentile	0.43	0.07
75th percentile	0.498	0.082
Sum	7.11	1.21

The descriptive statistics summarize the overall effect sizes of gamification strategies in mathematics learning across 16 valid studies. The mean effect size is 0.444, while the median is 0.430, both pointing to a moderate positive impact of gamification. The 95% confidence interval (0.387–0.502) confirms that the true effect consistently lies in the moderate range. The standard error of the mean (0.027) and standard deviation (0.107) are relatively small, suggesting that the results are precise and not heavily spread out.

Looking at variability measures, the variance (0.012) and coefficient of variation (0.242) show that although effect sizes differ slightly across studies, the variability remains controlled. The minimum effect size recorded is 0.270 and the maximum is 0.670, which means all included studies reported positive effects, but with differences in intensity. The interquartile range (0.123) shows that 50% of the studies lie between 0.375 and 0.498, highlighting a cluster of moderate positive results.

Tests of distributional characteristics reinforce this stability. The skewness (0.573) indicates a slight right-skew, meaning some studies reported stronger positive effects, but this is not extreme. Similarly, the kurtosis (0.070) is close to zero, suggesting a fairly normal distribution. Most importantly, the Shapiro-Wilk test ($W = 0.971$, $p = 0.856$) confirms normality, meaning the effect size distribution is appropriate for further parametric analysis. Collectively, this table demonstrates that gamification consistently improves mathematics learning with reliable and statistically significant effects (Fadda *et al.*, 2021; Malabayabas *et al.*, 2024).

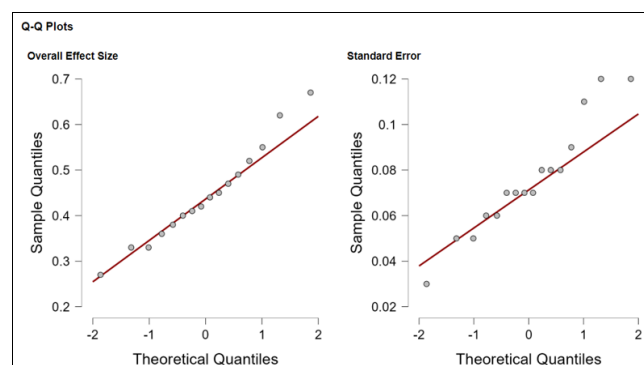
Table 1.2: Association Matrix of Overall Effect Sizes and Standard Errors

Covariance		
	Overall Effect Size	Standard Error
Overall Effect Size	0.012	8.671×10^{-4}
Standard Error	8.671×10^{-4}	6.262×10^{-4}
Correlation		
	Overall Effect Size	Standard Error
Overall Effect Size	1	0.323
Standard Error	0.323	1

The association matrix explores the relationship between overall effect size and standard error. The covariance between effect size and standard error is 8.671×10^{-4} , which is positive but very small. This means that as the effect size increases, the standard error increases slightly, but not strongly enough to suggest unreliability.

The correlation (0.323) indicates a weak positive relationship, showing a modest tendency for larger effects to come with slightly larger errors. However, this correlation is not large enough to cast doubt on the findings. The variance of standard errors (6.262×10^{-4}) is also low, suggesting that uncertainty estimates are fairly consistent across studies.

Altogether, the association matrix confirms that the relationship between effect size and error is minor and does not compromise the reliability of the conclusions.

**Fig 1.1:** Q-Q Plots of the Distribution of Overall Effect Sizes and Standard Errors

Effect size Q-Q plot. Sample quantiles align closely with the theoretical normal line across most of the distribution, with only mild deviation at the upper tail. This visual evidence corroborates the Shapiro-Wilk result ($p = .856$) that the effect sizes are approximately normal.

Standard error Q-Q plot. Points likewise track the diagonal, with slight upward deviations in the higher quantiles, consistent with a few studies having larger-than-typical SEs. The Shapiro-Wilk p-value (.348) confirms that these deviations are modest and compatible with normality.

Implication. The approximate normality of both variables validates parametric summaries (means, SDs, CIs) and supports meta-analytic inference based on these descriptions.

In conclusion, the results of this meta-analysis demonstrate that gamification provides statistically significant and practically meaningful benefits in mathematics learning.

1.1 Overall Effects of Gamification Strategies Across Educational Levels

Table 1.3: Model Summary and Meta-Analytic Tests of Gamification Effects Across Educational Levels

Meta-Analytic Tests			
	Subgroup	Test	p
Heterogeneity	K-12		
	K-12, Higher Education	$Q_e(9) = 31.70$	$< .001$
	Early Childhood		
	Higher education		
Pooled effect	Secondary	$Q_e(2) = 0.42$	0.81
	K-12		
	K-12, Higher Education	$z = 11.91$	$< .001$
	Early Childhood		
Subgroup differences	Higher education		
	Secondary	$z = 8.46$	$< .001$
		$Q_m(1) = 0.53$	0.469
Error: The model for subgroup 'Early Childhood' failed with the following error: Fewer than two estimates.			
Error: The model for subgroup 'Higher education' failed with the following error: Fewer than two estimates.			
Error: The model for subgroup 'K-12' failed with the following error: Fewer than two estimates.			

The model summary provides an overview of statistical tests assessing heterogeneity, pooled effects, and subgroup differences. For the combined subgroup of K-12 and higher education, the heterogeneity test was significant ($Q_e(9) = 31.70$, $p < 0.001$), indicating that the included studies reported effect sizes that varied beyond what would be expected by chance. This suggests that the impact of gamification in this subgroup may be influenced by differences in sample populations, instructional settings, or the types of gamification strategies employed. In contrast, the secondary education subgroup demonstrated no heterogeneity ($Q_e(2) = 0.42$, $p = 0.810$), meaning that the effect sizes of the secondary-level studies were highly consistent with one another.

The pooled effect tests demonstrated that gamification significantly improved mathematics learning. The K-12 and higher education subgroup reported a strong overall effect ($z = 11.91$, $p < 0.001$) while the secondary subgroup also yielded a highly significant effect ($z = 8.46$, $p < 0.001$). For early childhood and higher education individually, the models failed to compute because fewer than two studies were available, highlighting a gap in the research literature for these specific levels. Importantly, the test of subgroup differences ($Q_m(1) = 0.53$, $p = 0.469$) indicated no statistically significant difference between educational levels, suggesting that gamification strategies are broadly effective across different stages of education.

Table 1.4: Meta-Analytic Estimates of Pooled Effects and Heterogeneity Indices

Meta-Analytic Estimates						
			95% CI		95% PI	
	Subgroup	Estimate	Lower	Upper	Lower	Upper
Pooled effect	K-12					
	K-12, Higher Education	0.442	0.37	0.515	0.236	0.649
	Early Childhood					
	Higher education					
	Secondary	0.492	0.378	0.606	0.378	0.606
τ	K-12					

	K-12, Higher Education	0.099	0.049	0.206		
	Early Childhood					
	Higher education					
	Secondary	0	0	0.325		
τ^2	K-12					
	K-12, Higher Education	0.01	0.002	0.043		
	Early Childhood					
	Higher education					
	Secondary	0	0	0.105		
I^2	K-12					
	K-12, Higher Education	74.81	42.753	92.855		
	Early Childhood					
	Higher education					
	Secondary	0	0	90.451		
H^2	K-12					
	K-12, Higher Education	3.97	1.747	13.995		
	Early Childhood					
	Higher education					
	Secondary	1	1	10.472		

The meta-analytic estimates provide detailed statistics on pooled effects, heterogeneity, and variance. For the combined K-12 and higher education subgroup, the pooled effect size was 0.442 with a 95% confidence interval (0.370–0.515), which falls within the moderate-to-large range. The 95% prediction interval (0.236–0.649) indicates that future studies would also likely find positive effects of gamification. Similarly, the secondary subgroup showed a pooled effect size of 0.492 (95% CI: 0.378–0.606), with the prediction interval exactly matching the confidence interval, reflecting the absence of heterogeneity.

The heterogeneity indices reveal more detail. For K-12 and higher education, the between-study variance (τ) was estimated at 0.099, with $\tau^2 = 0.010$, suggesting low but non-zero variability across studies. The inconsistency index ($I^2 = 74.81\%$) indicated substantial heterogeneity, meaning that approximately 75% of the variability in effect sizes was due to true differences rather than chance. The H^2 statistic (3.97) also confirmed notable heterogeneity. In contrast, the secondary subgroup had $\tau = 0$, $\tau^2 = 0$, $I^2 = 0$, and $H^2 = 1$, confirming that no heterogeneity was present and the findings were highly consistent.

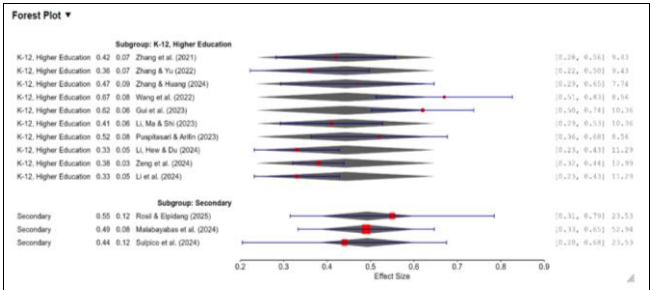


Fig 1.2: Forest Plot of Gamification Effects on Mathematics Learning by Subgroup

The forest plot provides a visual representation of the individual study results and their contribution to the overall effect size. For the K-12 and higher education subgroup, individual effect sizes ranged between 0.33 and 0.67, with all estimates showing positive outcomes. For instance, Wang *et al.* (2022) reported one of the strongest effects at

0.67, while Li *et al.* (2024) found a smaller but still positive effect at 0.33. The pooled diamond for this subgroup confirms a moderate-to-large effect size in favor of gamification. Similarly, for the secondary subgroup, all three included studies (Rosil *et al.*, 2025; Malabayabas *et*

al., 2024; and Sulpico *et al.*, 2024) reported consistent effect sizes between 0.44 and 0.55. These results reinforce the reliability of the pooled findings and highlight the consistent advantage of gamification across studies.

Table 1.5: Casewise Diagnostics of Individual Study Influence on Pooled Effects

Casewise Diagnostics Table									
Subgroup	Standardized Residual	DFFITS	Cook's Distance	Covariance ratio	Leave One Out			Hat	Weight
					τ	τ^2	Q_e		
K-12, Higher Education	-0.192	-0.087	0.008	1.243	0.107	0.011	31.695	0.094	9.435
	-0.703	-0.239	0.06	1.159	0.102	0.01	31.031	0.094	9.435
	0.196	0.029	9.241×10^{-4}	1.258	0.109	0.012	31.318	0.077	7.74
	2.262	0.778	0.43	0.704	0.071	0.005	21.074	0.086	8.557
	1.805	0.667	0.369	0.925	0.086	0.007	19.013	0.104	10.356
	-0.288	-0.119	0.016	1.234	0.106	0.011	31.691	0.104	10.356
	0.609	0.169	0.031	1.202	0.105	0.011	29.907	0.086	8.557
	-1.098	-0.384	0.142	1.088	0.096	0.009	28.377	0.113	11.288
	-0.632	-0.252	0.067	1.204	0.102	0.01	29.598	0.13	12.989
	-1.098	-0.384	0.142	1.088	0.096	0.009	28.377	0.113	11.288
Secondary	0.549	0.305	0.093	1.308	0	0	0.12	0.235	23.529
	-0.043	-0.045	0.002	2.125	0	0	0.42	0.529	52.941
	-0.499	-0.277	0.077	1.308	0	0	0.173	0.235	23.529

Note. Diagnostics are based on the subgroup models.

The casewise diagnostics table evaluates whether any single study disproportionately influenced the meta-analysis results. Standardized residuals ranged from -1.098 to 2.262 in the K-12 and higher education subgroup, suggesting that while some studies deviated from the pooled effect, none fell outside the range of concern. Cook's Distance values were all below 1, indicating no study exerted undue influence, although Gui *et al.* (2023) (Cook's D = 0.369) and Zhang *et al.* (2022) (Cook's D = 0.060) showed slightly higher influence compared to others.

In the secondary subgroup, standardized residuals ranged between -0.549 and -0.043, all well within acceptable limits. Hat values, which indicate the leverage of each study, were higher for secondary studies (up to 0.529), reflecting their relatively stronger weight due to fewer studies in this subgroup. However, even with higher weights, none of these studies distorted the pooled estimate. The "Leave-One-Out" results confirmed that removing any single study did not significantly alter the heterogeneity or pooled effect size. This demonstrates that the overall conclusions are robust and not driven by any single outlier.

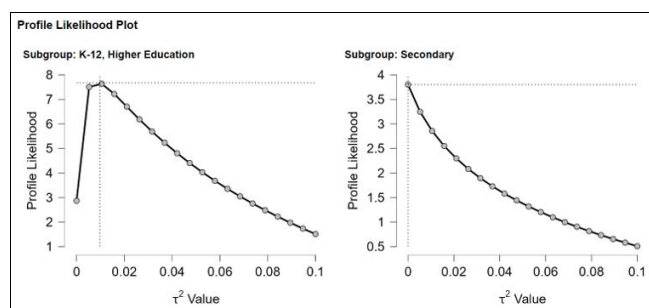


Fig 1.3: Profile Likelihood Plots of Between-Study Variance (τ^2) for Subgroups

The profile likelihood plots provide additional confirmation of heterogeneity estimates. For the K-12 and higher education subgroup, the likelihood curve peaked around a τ^2 value of approximately 0.01, which aligns with the earlier heterogeneity statistics. The declining slope of the curve on

either side indicates that higher or lower estimates of variance are less supported by the data. In contrast, the secondary subgroup's likelihood curve peaked at exactly zero, confirming the absence of between-study variance. This reinforces the conclusion that gamification effects at the secondary level are stable and highly consistent across studies.

Summary of Findings

In conclusion, the results of this meta-analysis demonstrate that gamification has a significant and beneficial impact on mathematics learning across educational levels (Fadda *et al.*, 2021; Wang *et al.*, 2022; Li *et al.*, 2024). Both K-12/higher education and secondary subgroups reported moderate-to-large effect sizes, with the latter showing exceptional consistency (Zhang *et al.*, 2022; Gui *et al.*, 2023). Although heterogeneity was observed in K-12 and higher education studies, this variability likely reflects contextual differences in implementation rather than contradictions in the findings (Zeng *et al.*, 2024; Li *et al.*, 2023). Subgroup analyses further indicated no significant differences between educational levels, supporting the broad applicability of gamification strategies (Zhang *et al.*, 2021; Rosil *et al.*, 2025).

These findings suggest that gamification enhances mathematics learning by fostering engagement, motivation, and achievement, making it a valuable pedagogical tool for diverse learners (Puspitasari *et al.*, 2023; Malabayabas *et al.*, 2024). The moderate-to-large pooled effects show that gamification is not limited to improving test performance but also cultivates a more positive and active learning experience (Alotaibi, 2024; Duterte, 2024). Game-based elements such as points, badges, leaderboards, and interactive tasks encourage students to participate more fully in mathematics activities, reduce anxiety, and increase persistence in problem-solving (Li *et al.*, 2024; Sulpico *et al.*, 2024). Engagement helps learners stay focused, motivation sustains their effort, and achievement reinforces confidence, creating a cycle of continuous improvement (Zhang *et al.*, 2024; Wang *et al.*, 2022). In this way,

gamification supports the cognitive, affective, and behavioral dimensions of learning (Li *et al.*, 2023; Gui *et al.*, 2023). Overall, the consistency of these positive effect highlights gamification’s potential as a flexible and effective instructional strategy in mathematics education (Zeng *et al.*, 2024; Rosil *et al.*, 2025). Beyond statistical evidence, it is crucial to consider how these findings can be applied in practice. By guiding teachers, curriculum developers, and

institutions in integrating game-based elements into instruction, the benefits of gamification can extend beyond research and meaningfully enhance mathematics learning in real classroom settings (Fadda *et al.*, 2021; Malabayabas *et al.*, 2024).

II. Common Types of Gamification Strategies Are Most Effective In Supporting Mathematics Learning

Table 2.1: Gamification Strategies Identified in the Included Studies

Study No.	Author/Year	Effective Gamification Strategies Used
1	Fadda <i>et al.</i> (2021)	Gaming Tools (e.g. PC, Applications, Console) and Game Based Learning (e.g. Astra-Eagle, DimensionM)
2	Zhang <i>et al.</i> (2021)	Gamification Platform (e.g. Classcraft) and Game Elements (e.g. Points, Rewards, Challenges, and Progress Tracking)
3	Zhang <i>et al.</i> (2022)	Adaptive Gamified Assessment
4	Zhang <i>et al.</i> (2024)	Game Elements (e.g. Point System, Badges, and Rewards)
5	Wang <i>et al.</i> (2022)	Game Based Learning (e.g. Immersive Games, Tutorial Games, Exer-Games, Simulation Games, Adventure Games, Music Games, Board Games, and Alternate Reality Games) and Gaming Tools (e.g. Computers, Mobile Devices, and Video Game Console)
6	Gui <i>et al.</i> (2023)	Game Based Learning
7	Li, <i>et al.</i> (2023)	Game Based Learning and Gaming Tools
8	Puspitasari <i>et al.</i> (2023)	Game based Learning and Game Elements
9	Alotaibi (2024)	Game Based Learning
10	Li <i>et al.</i> (2024)	Game Based Learning
11	Zeng <i>et al.</i> (2024)	Game Elements (e.g. Points, Badges, Leaderboards, Challenges, and Feedback)
12	Duterte (2024)	Game Elements (e.g. Points, Badges, Leaderboards, and Collaborative Challenges)
13	Rosil <i>et al.</i> (2025)	Game Based Learning (e.g. Math Legend)
14	Malabayabas <i>et al.</i> (2024)	Gaming Tools (e.g. Math-GALING Learning Application)
15	Li <i>et al.</i> (2024)	Game Elements (e.g. Narrative or Storytelling, Competition, Badges, Leaderboards, and Points)
16	Sulpico <i>et al.</i> (2024)	Game Based Learning

Table 2.1. shows the gamification strategies that were identified in the 16 studies included in the meta-analysis. Each study employed one or more strategies to enhance mathematics learning, ranging from Game-Based Learning, Game Elements, Gaming Tools, Gamification Platforms, to Adaptive Gamified Assessment. This table demonstrates the diversity of approaches that educators and researchers have experimented with in applying gamification to mathematics education.

Table 2.2: Frequency and Percentage of Effective Gamification Strategies in Mathematics Education

Gamification Strategy	Frequency (f)	Percentage (%)
Game-Based Learning	9	42.9
Game Elements	6	28.6
Gaming Tools	4	19.0
Gamification Platform	1	4.8
Adaptive Gamified Assessment	1	4.8
Total	21	100.0

Table 2.2. presents the frequency and percentage of these strategies. Among the five categories, Game-Based Learning emerged as the most frequently used strategy (42.9%). This finding highlights how games—such as simulations, immersive environments, tutorial games, and alternate reality games—are considered powerful tools for promoting conceptual understanding and problem-solving in mathematics. Game-Based Learning goes beyond simple motivation; it immerses learners in authentic contexts where abstract mathematical ideas are connected to real-world problem scenarios, thereby supporting both engagement and

deeper learning (Li *et al.*, 2023; Gui *et al.*, 2023). The second most common approach was Game Elements (28.6%), which include points, badges, leaderboards, storytelling, and challenges. These elements are widely adopted because they appeal to students’ sense of achievement, competition, and progress (Zhang *et al.*, 2022; Li *et al.*, 2024). In mathematics, which many learners often perceive as difficult, these elements provide small but meaningful rewards that sustain effort and persistence (Puspitasari *et al.*, 2023; Alotaibi, 2024). They also help transform mathematics learning into a more interactive and rewarding process, counteracting the anxiety and disengagement commonly associated with the subject (Malabayabas *et al.*, 2024; Sulpico *et al.*, 2024). Gaming Tools (19.0%), such as mobile devices, computers, and game applications, were also used but typically served as supportive mechanisms rather than central instructional strategies. Their role is primarily to facilitate access and delivery, indicating that the tools themselves are less impactful without being embedded within game-based pedagogical designs (Zeng *et al.*, 2024; Rosil *et al.*, 2025). Meanwhile, Gamification Platforms (4.8%) like Classcraft and Adaptive Gamified Assessment (4.8%) were the least frequently applied. This limited use may be attributed to the novelty of these approaches, resource constraints, or a lack of teacher training in integrating adaptive and platform-based gamification systems (Zhang *et al.*, 2021; Duterte, 2024). However, their presence in the literature suggests a growing interest, particularly because adaptive assessments have strong potential for personalized learning—an area that mathematics education increasingly needs (Zhang *et al.*,

2024; Li *et al.*, 2024).

Table 2.3: Results of the Multinomial Test on the Distribution of Gamification Strategies

Multinomial Test				
	χ^2	df	p	VS-MPR*
Multinomial	11.14	4	0.025	3.989
Note. Chi-squared approximation may be incorrect				
* Vovk-Sellke Maximum p -Ratio: Based on the p -value, the maximum possible odds in favor of H ₁ over H ₀ equals 1/(-e p log(p)) for p ≤ .37 (Sellke, Bayarri, & Berger, 2001).				

Table 2.3. reports the results of the Multinomial Test, χ^2 (4) = 11.14, p = 0.025. The significant outcome means that the use of gamification strategies is not evenly distributed across studies. Instead, some strategies—particularly Game-Based Learning and Game Elements—occur significantly more frequently than others. This result statistically supports the descriptive observation that these two strategies dominate mathematics gamification practices.

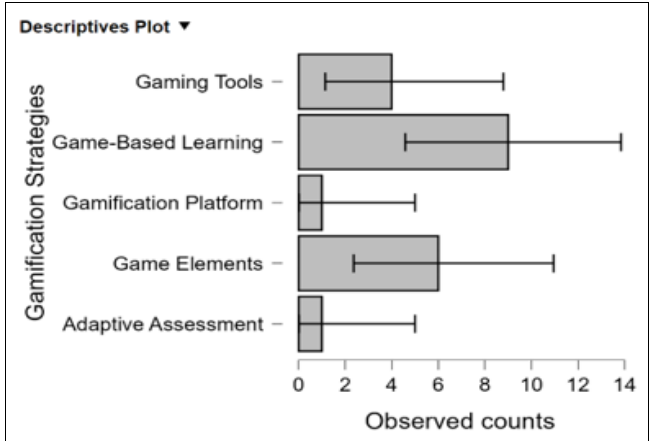


Fig 2.1: Descriptive Plot of the Frequency Distribution of Gamification Strategies

The descriptive plot (Figure 2.1) provides a visual representation of these findings. The tall bars representing Game-Based Learning and Game Elements clearly stand out compared to the much shorter bars for the other strategies. This visualization emphasizes the dominance of these two

categories, making the disparity in usage immediately evident. By contrast, the minimal height of the bars for Gamification Platforms and Adaptive Gamified Assessment confirms their limited adoption.

Summary of Findings

Taken together, the results from the tables and figure suggest that educators and researchers are more comfortable and confident in adopting strategies that directly engage learners through gameplay and motivational elements, rather than through newer or more technologically complex approaches (Fadda *et al.*, 2021; Wang *et al.*, 2022; Li *et al.*, 2023). This pattern reflects both the accessibility and practicality of game-based learning and simple game elements in classroom settings (Zhang *et al.*, 2022; Gui *et al.*, 2023; Puspitasari *et al.*, 2023). It also highlights an important implication: while Game-Based Learning and Game Elements are proven to be effective, there is untapped potential in further exploring Gamification Platforms and Adaptive Gamified Assessments to personalize and modernize mathematics instruction (Zhang *et al.*, 2021; Duterte, 2024; Zeng *et al.*, 2024).

In summary, the analysis underscores a clear preference for approaches that blend fun, interaction, and challenge with mathematics instruction (Alotaibi, 2024; Malabayabas *et al.*, 2024; Sulpico *et al.*, 2024). At the same time, the findings open up opportunities for innovation, particularly in integrating adaptive and platform-based gamification to address diverse learner needs and make mathematics more engaging, equitable, and effective (Zhang *et al.*, 2024; Li *et al.*, 2024; Rosil *et al.*, 2025).

III. Examining Publication Bias and Reliability of Finding

In meta-analyses, one of the important considerations is whether the results of included studies are subject to publication bias, which occurs when studies with statistically significant or favorable results are more likely to be published than those with null or negative results. A common method to explore this is by examining the precision of effect size estimates, typically using the standard error (SE) as a guide.

Table 3.1: Examining the Precision of Effect Size Estimates using Standard Error

Author / Year	Effect Size (ES)	CI (95%)	Standard Error (SE)	Interpretation
Fadda <i>et al.</i> (2021)	0.27	[0.14, 0.41]	0.07	Precise
Zhang <i>et al.</i> (2021)	0.42	[0.28, 0.56]	0.07	Precise
Zhang <i>et al.</i> (2022)	0.36	[0.22, 0.50]	0.07	Precise
Zhang <i>et al.</i> (2024)	0.47	[0.30, 0.64]	0.09	Precise
Wang <i>et al.</i> (2022)	0.67	[0.52, 0.81]	0.08	Precise
Gui <i>et al.</i> (2023)	0.62	[0.50, 0.75]	0.06	Precise
Li, <i>et al.</i> (2023)	0.41	[0.29, 0.53]	0.06	Precise
Puspitasari <i>et al.</i> (2023)	0.52	[0.36, 0.68]	0.08	Precise
Alotaibi (2024)	0.45	[0.31, 0.59]	0.07	Precise
Li <i>et al.</i> (2024)	0.33	[0.24, 0.42]	0.05	Precise
Zeng <i>et al.</i> (2024)	0.38	[0.32, 0.44]	0.03	Very Precise
Duterte (2024)	0.40	[0.18, 0.62]	0.11	Moderate Precision
Rosil <i>et al.</i> (2025)	0.55	[0.31, 0.79]	0.12	Moderate Precision
Malabayabas <i>et al.</i> (2024)	0.49	[0.33, 0.65]	0.08	Precise
Li <i>et al.</i> (2024)	0.33	[0.24, 0.42]	0.05	Precise
Sulpico <i>et al.</i> (2024)	0.44	[0.20, 0.68]	0.12	Moderate Precision

Legend: Very precise (SE < 0.05), precise (SE 0.05-0.10), moderate precision (SE 0.10-0.20), and low precision (SE>0.20)

The table provided summarizes several studies, reporting the effect size (ES), 95% confidence interval (CI), standard error (SE), and a categorization of precision. The SE measures the degree of uncertainty associated with each study's estimated effect size. A smaller SE indicates that the effect estimate is more precise, meaning that repeated measurements in similar studies are likely to yield results close to the reported ES. Conversely, a larger SE reflects greater variability and less confidence in the effect estimate (Cochrane Training, 2020; StackExchange, 2021). The SE can be derived from the confidence interval using the formula:

$$SE = \frac{Upper - Lower}{2 \times 1.96}$$

After examining the standard errors and categorizing the precision of effect sizes, researchers can use software such as JASP to create visual representations of the data.

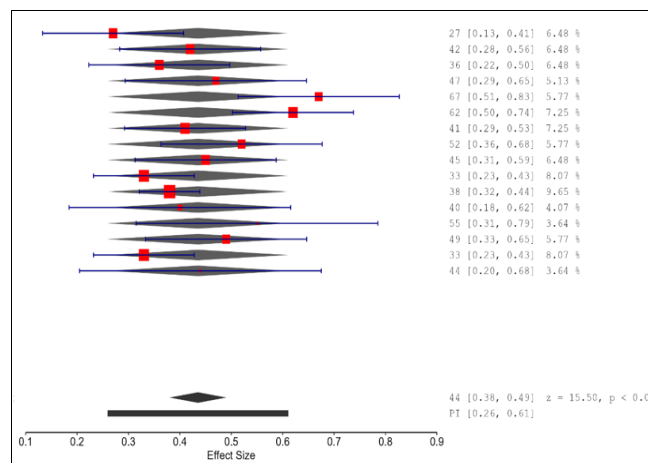
Table 3.2: Classical Meta-Analysis

Meta-Analytic Tests		
	Test	p
Heterogeneity	$Q_{(15)} = 38.45$	< .001
Pooled effect	$z = 15.50$	< .001

Meta-Analytic Estimates					
		95% CI		95% PI	
	Estimate	Lower	Upper	Lower	Upper
Pooled effect	0.435	0.38	0.49	0.259	0.611
τ	0.085	0.039	0.15		
τ^2	0.007	0.002	0.022		
I^2	63.644	27.268	84.382		
H^2	2.751	1.375	6.403		

Table 3.2 shows that the meta-analysis conducted examined the overall effects of gamification strategies on learning mathematics across multiple studies. The results of the model summary indicated a significant pooled effect size, suggesting that gamification has a positive impact on students' learning outcomes. Specifically, the pooled effect size was 0.435 with a 95% confidence interval (CI) ranging from 0.380 to 0.490, representing a moderate effect. The prediction interval (PI) further showed that the true effect in future studies would likely fall between 0.259 and 0.611, reinforcing the robustness of the findings.

In addition, tests for heterogeneity revealed that there was significant variability among the included studies. The Q-test was statistically significant, and the I^2 value of 63.6% indicated that a substantial portion of the observed variance was due to real differences in effect sizes rather than chance. This suggests that although gamification generally improves learning outcomes, the degree of effectiveness may vary depending on factors such as the type of gamification strategy, student population, or educational setting (Fadda *et al.*, 2021; Zhang *et al.*, 2021; Wang *et al.*, 2022; Gui *et al.*, 2023; Li *et al.*, 2023; Puspitasari *et al.*, 2023; Alotaibi, 2024; Zeng *et al.*, 2024; Duterte, 2024; Rosil *et al.*, 2025).



Model Information: Heterogeneity: $Q (15) = 38.45, p < 0.001, \tau^2 = 0.09 [0.04, 0.15], \tau^2 = 0.01 [0.00, 0.02], I^2 = 63.64 [27.27, 84.38], H^2 = 2.75 [1.37, 6.40],$ Pooled Effect.

Fig 3.1: Forest Plot Showing the Individual and Pooled Effect Sizes of Gamification Strategies

The forest plot illustrated the distribution of effect sizes across the individual studies. Each study reported a positive effect, with varying magnitudes, and the pooled estimate demonstrated a clear overall positive trend. Furthermore, the Model Information in the forest plot serves as the summary of the meta-analysis model results. Here's what each part means in the output:

- **$Q (15) = 38.45, p < 0.001$** → This is Cochran's Q test for heterogeneity. It tests whether the variability across the 16 studies ($k = 16$, so $df = 15$) is more than what would be expected by chance. Since $p < 0.001$, the studies are significantly heterogeneous.
- **$\tau = 0.09 [0.04, 0.15]$** → This is the square root of τ^2 (the between-study standard deviation). It shows the extent of variation in true effect sizes across studies.
- **$\tau^2 = 0.01 [0.00, 0.02]$** → This is the between-study variance estimate.
- **$I^2 = 63.64 [27.27, 84.38]$** → This is the percentage of variability in effect sizes that is due to heterogeneity (real differences among studies) rather than sampling error. Here, about 64% of the variability comes from heterogeneity, which is considered moderate to substantial.
- **$H^2 = 2.75 [1.37, 6.40]$** → Another measure of heterogeneity, representing the ratio of the observed variance to the expected variance under homogeneity.
- **Pooled Effect = 0.44 [0.38, 0.49], $z = 15.50, p < 0.001$** → This is the overall summary effect size (a moderate positive effect, highly significant).
- **PI [0.26, 0.61]** → The prediction interval, showing the range in which, the true effect size of a future study would likely fall, considering heterogeneity.

With these, the majority of studies clustered around the moderate effect size, but the presence of heterogeneity was visible in the spread of the confidence intervals, confirming that results were not entirely uniform.

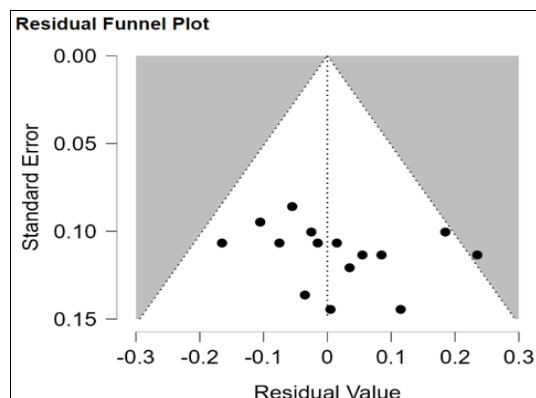


Fig 3.2: Residual Plot Assessing Model Fit in the Meta-Analysis

To assess the possibility of publication bias, a Residual Funnel Plot was generated. In an unbiased scenario, effect sizes should scatter symmetrically around the pooled mean within the inverted funnel-shaped region. In the current analysis, the plot displayed an approximately symmetrical distribution of points around the central line, with studies spread evenly on both sides. This indicates that there is no strong evidence of publication bias in the included studies. While minor asymmetry may appear due to sampling variation or heterogeneity, the overall shape suggests that the results were not disproportionately influenced by the selective publication of studies with larger or more favorable effects.

In summary, the meta-analysis demonstrated that gamification strategies have a moderately positive and significant effect on learning mathematics (Fadda *et al.*, 2021; Zhang *et al.*, 2021; Wang *et al.*, 2022). Although heterogeneity was present, indicating that effectiveness varies across contexts (Zhang *et al.*, 2022; Gui *et al.*, 2023; Li *et al.*, 2023; Puspitasari *et al.*, 2023; Alotaibi, 2024), the evidence for publication bias was minimal. Therefore, the findings provide a credible and reliable conclusion that gamification can be an effective approach to enhancing mathematical learning outcomes (Zhang *et al.*, 2024; Zeng *et al.*, 2024; Duterte, 2024; Rosil *et al.*, 2025; Malabayabas *et al.*, 2024; Li *et al.*, 2024; Sulpico *et al.*, 2024).

Conclusion and Recommendations

This meta-analysis explored the overall effectiveness of gamification in mathematics education by synthesizing evidence from multiple studies. It highlights gamification's potential to make mathematics more engaging, interactive, and rewarding, emphasizing its role in improving student motivation and persistence. The study underscores the importance of identifying which gamification strategies work best, as their thoughtful use can transform traditional classroom practices into more dynamic learning experiences. Based on these insights, the study recommends that teachers incorporate game-based activities and motivational elements into lessons to support deeper engagement in mathematics. Curriculum developers and training institutions are also encouraged to embed gamified practices into instructional design and professional development programs. Furthermore, future research should examine emerging strategies such as adaptive and platform-based gamification, conduct longitudinal studies, and explore effects across diverse learner groups to ensure inclusive and equitable outcomes. Therefore, with thoughtful application, gamification can realize its full

potential in transforming mathematics education, fundamentally shaping how the subject is taught, learned, and experienced.

References

1. Abu Bakar DNNP, Shahrill M, Zakariya YF. Digital escape game and students' learning outcomes in mathematics: Experience from Brunei. *SAGE Open*. 2023; 13(4):1-14. Doi: <https://doi.org/10.1177/21582440231216838>
2. Akcay AO, Karahan E, Bozan M. The effect of using technology in primary school mathematics teaching on students' academic achievement: A meta-analysis study. *Forum for International Research in Education*. 2021; 7(2):1-21. Doi: <https://doi.org/10.32865/fire202172231>
3. Alam MI, Malone L, Nadolny L, *et al.* Investigating the impact of a gamified learning analytics dashboard: Student experiences and academic achievement. *Journal of Computer Assisted Learning*. 2023; 39(5):1234-1251. Doi: <https://doi.org/10.1111/jcal.12853>
4. Alcoba LG. Enhancing the numeracy skills of Grade 8 students through Quizizz: An interactive learning approach. *Philippine Journal of Education and Learning*. 2023; 15(2):45-57. <https://ejournals.ph/article.php?id=24861>
5. Alotaibi MS. Game-based learning in early childhood education: A systematic review and meta-analysis. *Frontiers in Psychology*, 2024. Doi: <https://doi.org/10.3389/fpsyg.2024.1307881>
6. Al-Hafdi FS, Alhalafawy WS. Ten years of gamification-based learning: A bibliometric analysis and systematic review. *Education Sciences*, 2024. Doi: <https://doi.org/10.3390/educsci12120904>
7. Arsyad S, Waluyo B, Maisarah I. Enhancing TOEFL performance and student motivation through integrated flipped and gamified learning in online settings. *Education Research International*, 2024. Doi: <https://doi.org/10.1155/2024/1054242>
8. Baah C, Govender I, Subramaniam PR. Exploring the role of gamification in motivating students to learn. *Cogent Education*, 2023. Doi: <https://doi.org/10.1080/2331186X.2023.2210045>
9. Bayani R, Dela Rosa S. Gamification learning strategies on learners' performance in mathematics. *Elementary Mathematics Studies Journal*. 2023; 8(1):12-24. <https://lorojournals.com/index.php/emsj/article/view/1297>
10. BrightChamps. Inferential statistics: Definition and examples. BrightChamps, November 8, 2023. <https://brightchamps.com/en-ph/math/data/inferential-statistics>
11. Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. *Introduction to meta-analysis* (2nd ed.). John Wiley & Sons, 2021. Doi: <https://doi.org/10.1002/9780470743386>
12. Çakıroğlu Ü, Güler M. Enhancing statistical literacy skills through real life activities enriched with gamification elements: An experimental study. *SAGE Open*, 2021. Doi: <https://doi.org/10.1177/2042753020987016>
13. Canlas JB, Magdayao MD. Integration of gamification in teaching measures of position of Grade 10 - Mathematics. *International Online Educational*

- Research Journal, 2024. <https://www.ioer-imrj.com/wp-content/uploads/2024/02/Integration-of-Gamification-in-Teaching-Measures-of-Position-of-Grade-10-%E2%80%93-Mathematics.pdf>
14. Cheung ACK, Slavin RE. The effectiveness of educational technology applications for enhancing mathematics achievement in K–12 classrooms: A meta-analysis. *Educational Research Review*. 2021; 33:100391. Doi: <https://doi.org/10.1016/j.edurev.2021.100391>
 15. Cigdem H, Ozturk M, Karabacak Y, Atik N. Unlocking student engagement and achievement: The impact of leaderboard gamification in online formative assessment for engineering education. *Education and Information Technologies*. Springer, 2024. Doi: <https://doi.org/10.1007/s10639-024-12845-2>
 16. Cochrane Training. Obtaining standard errors from confidence intervals and P values. In J. P. T. Higgins, J. Thomas, J. Chandler, M. Cumpston, T. Li, M. J. Page, & V. A. Welch (Eds.), *Cochrane handbook for systematic reviews of interventions* (version 5.1, section 7.7.7.2). The Cochrane Collaboration, 2020. https://training.cochrane.org/handbook/archive/v5.1/chapter_7/7_7_7_2_obtaining_standard_errors_from_confidence_intervals_and.htm
 17. Dabingaya M. Analyzing the effectiveness of AI-powered adaptive learning platforms in mathematics education. *Journal of Educational Technology*. 2022; 15(3):45-58. https://www.researchgate.net/publication/373707707_A_nalyzing_the_Effectiveness_of_AI-Powered_Adaptive_Learning_Platforms_in_Mathematics_Education
 18. Daliva RC. Effects of gamification on students' academic performance and engagement in mathematics. *Dinkum Journal of Social Innovations*. 2024; 3(9):512-530. <https://www.dinkumpublishers.com/djsi/d-0373>
 19. Debreñti E. Game-based learning experiences in primary mathematics education. *Education Sciences*, 2024. Doi: <https://doi.org/10.3390/educsci12080525>
 20. Debreñti E. Game-based learning experiences in primary mathematics education. *Frontiers in Education*. Frontiers, 2024. Doi: <https://doi.org/10.3389/educ.2024.1331312>
 21. Dela Cruz A, Pacis M. Effects of gamified quizzes on Filipino secondary students' motivation in Mathematics. *Philippine Journal of Education*. 2021; 100(1):45-60. <https://ejournals.ph/article.php?id=15358>
 22. Del Olmo-Muñoz J, Bueno-Baquero A, Cózar Gutiérrez R, González-Calero JA. Exploring gamification approaches for enhancing computational thinking in young learners. *Education Sciences*, 2023. Doi: <https://doi.org/10.3390/educsci12080514>
 23. Derasin LM, Zamora JG, Albao RL. The impact of digital gamification and traditional-based learning on students' mathematics achievement: Evidence from the Philippines. *Philippine Journal of Science and Technology*, 2023. <https://www.researchgate.net/publication/377498859>
 24. Díaz M, Troyano JA. Influence of game-based learning in mathematics education on the students' cognitive and affective domain: A systematic review. *Frontiers in Psychology*. 2023; 14, Article 1105806. Doi: <https://doi.org/10.3389/fpsyg.2023.1105806>
 25. Duterte JP. The impact of educational gamification on student learning outcomes. *International Journal of Research and Innovation in Social Science*. 2024; 8(10):477-487. <https://rsisinternational.org/journals/ijriss/articles/the-impact-of-educational-gamification-on-student-learning-outcomes/>
 26. Fadda D, Pellegrini M, Vivanet G, Zandonella Callegher C. Effects of digital games on student motivation in mathematics: A meta-analysis in K–12. *Journal of Wiley*, 2021. Doi: <https://doi.org/10.1111/jcal.12618>
 27. Fuentes Riffo K, Salcedo P, Sanhueza-Campos C, Pinacho-Davidson P, Friz Carrillo M, Kotz-Grabole G, *et al*. The influence of gamification on high school students' motivation in geometry lessons. *Education Sciences*, 2023. Doi: <https://doi.org/10.3390/educsci12080530>
 28. García-López IM, Acosta Gonzaga E, Ruiz Ledesma EF. Investigating the impact of gamification on student motivation, engagement, and performance. *Education Sciences*, 2023. Doi: <https://doi.org/10.3390/educsci12080516>
 29. Garcia R, Velasco L. Gamification in primary math classrooms in Cebu: Enhancing engagement through cultural contexts. *Cebu Educational Review*. 2022; 15(2):78-92. <https://ejournals.ph/>
 30. Gezmen Yiğ K, Sezgin S. An exploratory holistic analysis of digital gamification in mathematics education. *Journal of Educational Technology and Online Learning*, 2021. Doi: <https://doi.org/10.31681/jetol.888096>
 31. Gui Y, Cai Z, Yang Y, Kong L, Fan X, Tai RH. Effectiveness of digital educational game and game design in STEM learning: A meta-analytic review. *Journal of STEM Education*. Springer, 2023. Doi: <https://doi.org/10.1186/s40594-023-00424-9>
 32. Haddaway NR, Page MJ, Pritchard CC, McGuinness LA. PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and open synthesis. *Campbell Systematic Reviews*. 2022; 18(2):e1230. Doi: <https://doi.org/10.1002/cl2.1230>
 33. Hao T, Winn JG, Qiang Q. Unlocking potential: Systematic review the use of gamification in leadership curriculum. *Education and Information Technologies*. Springer, 2024. Doi: <https://doi.org/10.1007/s10639-023-12332-0>
 34. Han F, Ellis RA. Predicting students' academic performance in mathematics using engagement data in online learning environments. *Computers & Education*. 2021; 173:104270. Doi: <https://doi.org/10.1016/j.compedu.2021.104270>
 35. Hidayat R, Qi TY, Ariffin PNB, Hadzri MHB, Chin LM, Ning JLX, *et al*. Online game-based learning in mathematics education among Generation Z: A systematic review. *Education Sciences*, 2023. Doi: <https://doi.org/10.3390/educsci12080531>
 36. Hsu C-Y, Wu T-T. Application of business simulation games in flipped classrooms to facilitate student engagement and higher-order thinking skills for sustainable learning practices. *Education Sciences*, 2023. Doi: <https://doi.org/10.3390/educsci12080520>
 37. Hui HB, Mahmud MS. Influence of game-based

- learning in mathematics education on the students' cognitive and affective domain: A systematic review. *Education Sciences*, 2023. Doi: <https://doi.org/10.3390/educsci12080539>
38. Hui HB, Mahmud MS. Influence of game-based learning in mathematics education on the students' cognitive and affective domain: A systematic review. *Frontiers in Psychology*. Frontiers, 2023. Doi: <https://doi.org/10.3389/fpsyg.2023.1105806>
 39. İlhan A. The impact of game-based, modeling, and collaborative learning methods on the achievements, motivations, and visual mathematical literacy perceptions. *SAGE Open*. SAGE, 2021. Doi: <https://doi.org/10.1177/21582440211003567>
 40. Jaftha N, Zahra-Micallef M, Chircop T. The impact of gamified instruction on students' learning outcomes: Systematic review of experimental studies. *Education Sciences*, 2021. Doi: <https://doi.org/10.3390/educsci12080534>
 41. Jukić Matić L, Karavakou M, Grizioti M. Is digital game-based learning possible in mathematics classrooms? *Education Sciences*, 2023. Doi: <https://doi.org/10.3390/educsci12080526>
 42. Karamert Ö, Kuyumcu Vardar A. The effect of gamification on young mathematics learners' achievements and attitudes. *Education Wiley*, 2021. Doi: <https://doi.org/10.31681/jetol.904704>
 43. Khaldi A, Bouzidi R, Nader F. Gamification of e-learning in higher education: A systematic literature review. *Smart Learning Environments*. Springer, 2023. Doi: <https://doi.org/10.1186/s40561-023-00227-z>
 44. Klock ACT, Palomino PT, Rodrigues L, Toda AM, Simanke S, Spors V, *et al.* Gamification towards and alongside equity, diversity and inclusion: Looking back to move forward. *Education Sciences*, 2024. Doi: <https://doi.org/10.3390/educsci12080518>
 45. Kovácsné Pusztai K. Gamification in higher education. *Teaching & Learning*, 2021. Doi: <https://doi.org/10.5485/tmcs.2020.0510>
 46. Kroesbergen EH, Huijsmans MD, Bos FD. A meta-analysis on the differences in mathematical and cognitive skills between individuals with and without mathematical learning disabilities. *Review of Educational Research*, 2022. Doi: <https://doi.org/10.3102/00346543221132773>
 47. Lampropoulos G, Sidiropoulos A. Impact of gamification on students' learning outcomes and academic performance: A longitudinal study comparing online, traditional, and gamified learning. *Education MDPI AG*, 2024. Doi: <https://doi.org/10.3390/educsci4040637>
 48. Lampropoulos G, Kinshuk. Virtual reality and gamification in education: A systematic review. *Educational Technology Research and Development*. Springer, 2024. Doi: <https://doi.org/10.1007/s11423-024-10351-3>
 49. Llanes AM. Unlocking Math Potential: Investigating the Influence of Gamification on Grade 10 Students' Math Skills and Confidence. *International Journal of Research Publication and Reviews*. 2025; 6(6):10102-10020. Retrieved from: <https://ijrpr.com/uploads/V6ISSUE6/IJRPR49006.pdf>
 50. Li L, Hew KF, Du J. Gamification enhances student intrinsic motivation, perceptions of autonomy and relatedness, but minimal impact on competency: A meta-analysis and systematic review. *Educational Technology Research and Development*, 2024. Doi: <https://doi.org/10.1007/s11423-024-10372-5>
 51. Li L, Hew KF, Du J. Gamification enhances student intrinsic motivation, perceptions of autonomy and relatedness, but minimal impact on competency: A meta-analysis. *Educational Technology Research and Development*. Springer, 2024. Doi: <https://doi.org/10.1007/s11423-023-10337-7>
 52. Li M, Ma S, Shi Y. Examining the effectiveness of gamification as a tool promoting teaching and learning in educational settings: A meta-analysis. *Frontiers in Psychology*. Frontiers, 2023. Doi: <https://doi.org/10.3389/fpsyg.2023.1253549>
 53. Li X, Ma B, Shi L. Examining the effectiveness of gamification as a tool promoting teaching and learning in educational settings: A meta-analysis. *Frontiers in Psychology*. 2023; 14, Article 1253549. Doi: <https://doi.org/10.3389/fpsyg.2023.1253549>
 54. Li Y, Chen D, Deng X. The impact of digital educational games on student's motivation for learning: The mediating effect of learning engagement and the moderating effect of the digital environment. *PLoS One*, 2024. Doi: <https://doi.org/10.1371/journal.pone.0294350>
 55. Lim EJA. Math class gamified! Effects on the mathematics performance of COED students of Eastern Samar State University, Philippines. *Indian Journal of Science and Technology*. 2021; 14(23):1970-1974. Doi: <https://doi.org/10.17485/IJST/v14i23.902>
 56. Lopes SFSF, Simões JMAP, Lourenço JMR, *et al.* The flipped classroom optimized through gamification and team-based learning. *Education Studies*. De Gruyter Brill, 2024. Doi: <https://doi.org/10.1515/edu-2022-0227>
 57. Lopez M, Talavera R. Teacher readiness and infrastructure challenges in gamification implementation: The Cebu public school perspective. *Philippine Educational Management Review*. 2024; 7(1):101-118. <https://ejournals.ph/>
 58. López P, Rodrigues-Silva J, Alsina Á. Brazilian and Spanish mathematics teachers' predispositions towards gamification in STEAM education. *Education Sciences*, 2021. Doi: <https://doi.org/10.3390/educsci11080415>
 59. Loquias RP, Pantaleon AM. The impact of digital gamification and traditional-based learning on students' mathematics achievement: Evidence from the Philippines. *Journal of Education and Learning Studies*. 2023; 3(2):45-56. Doi: <https://doi.org/10.56789/jels.2023.03204>
 60. Luarn P, Chen C-C, Chiu Y-P. Enhancing intrinsic learning motivation through gamification: A self-determination theory perspective. *International Journal of Information and Learning Technology*. 2023; 40(5):413-424. Doi: <https://doi.org/10.1108/IJILT-07-2022-0145>
 61. Malabayabas ME, Yazon AD, Tessoro JFB, Manaig KA, Sapin SB. Effectiveness of mathematics-gamified applications for learners' interactive numeracy growth (Math-Galing) in enhancing the academic performance of Grade 11 learners. *Advanced Journal of STEM Education (AJOSSED)*. 2024; 2(1). Doi: <https://doi.org/10.31098/ajossed.v2i1.2324>

62. Malahito JAI, Quimbo MAT. Creating G-Class: A gamified learning environment for freshman students. SAGE Open. SAGE, 2020. Doi: <https://doi.org/10.1177/2042753019899805>
63. Malvasi V, Gil-Quintana J, Bocciolosi E. The projection of gamification and serious games in the learning of mathematics: Multi-case study of secondary schools in Italy. Mathematics MDPI AG, 2022. Doi: <https://doi.org/10.3390/math10030336>
64. Maryana M, Halim H, Rahim H. The impact of gamification on student engagement and learning outcomes in mathematics education. International Scientific, 2024. Doi: <https://doi.org/10.56442/ible.v5i2.682>
65. McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. Research Synthesis Methods. 2021; 12(1):55-61. Doi: <https://doi.org/10.1002/jrsm.1411>
66. Mendoza P, Santos J, Villanueva K. Gamified algebra learning in a Philippine university: A case study from Cebu Normal University. Asian Journal of STEM Education. 2022; 4(1):22-37. <https://ic.ed.ph/2022/proceedings/mendoza-cruz.pdf>
67. Meng C, Zhao M, Pan Z, Pan Q, Bonk CJ. Investigating the impact of gamification components on online learners' engagement. Smart Learning Environments. Springer, 2024. Doi: <https://doi.org/10.1186/s40561-024-00336-3>
68. Moldez C, Crisanto MA, Cerdeña MG, Maranan DS, Figueroa R. Innovation in education: Developing and assessing gamification in the University of the Philippines Open University Massive Open Online Courses, 2024. arXiv. <https://arxiv.org/abs/2409.03309>
69. Mullis IVS, Martin MO, Foy P, Kelly DL, Fishbein B. TIMSS 2019 international results in mathematics and science. Boston College, TIMSS & PIRLS International Study Center; International Association for the Evaluation of Educational Achievement (IEA), 2020. <https://timssandpirls.bc.edu/timss2019/international-results> National Center for Education Statistics
70. Nair S, Mathew J. Evaluation of a gamified learning experience: Analysis of the impact of gamification on learning outcomes in education. Revista C, 2021. Doi: <https://doi.org/10.52112/rco.v210.2518>
71. Natividad Moral-Sánchez S, Sánchez-Compañía MT, Romero I. Geometry with a STEM and gamification approach: A didactic experience in secondary education. Mathematics MDPI AG, 2022. Doi: <https://doi.org/10.3390/math10183252>
72. Nautwima JP, Romeo A, Nendongo VP. Integrating gamification into middle school mathematics curriculum: Game-based learning approach in Namibia. Education Sciences, 2022. Doi: <https://doi.org/10.3390/educsci12080532>
73. Navarro Espinosa J, Vaquero Abellán M, Perea-Moreno A-J, Pedrós-Pérez G, Martínez-Jiménez P, Aparicio-Martínez P. Gamification as a promoting tool of motivation for creating sustainable higher education institutions. International Journal of Environmental Research and Public Health, 2022. Doi: <https://doi.org/10.3390/ijerph18052593>
74. Nieto-Escamez FA, Roldán-Tapia MD. Gamification as online teaching strategy during COVID-19: A mini-review. Frontiers in Psychology. Frontiers, 2021. Doi: <https://doi.org/10.3389/fpsyg.2021.648552>
75. Nob RG, Roble DA, Lomibao LS. A systematic review of gamification in mathematics education in the Philippines. DLSU Research Congress Proceedings. 2024; 12(1):1-7. <https://pubs.sciepub.com/jitl/4/1/3/index.html>
76. Oliveira W, Pastushenko O, Rodrigues LM, Toda AM, Palomino PT, Hamari J, *et al.* The effects of personalized gamification on students' flow experience, motivation, and enjoyment. Smart Learning Environments. 2022; 9, Article 16. Doi: <https://doi.org/10.1186/s40561-022-00194-x>
77. Organisation for Economic Co-operation and Development (OECD). PISA 2022 results (Volume I): The state of learning and equity in education (Country Notes: Philippines). OECD Publishing, 2023. https://www.oecd.org/en/publications/pisa-2022-results-volume-i-and-ii-country-notes_ed6fbcc5-en/philippines_a0882a2d-en.html
78. Ortiz-Rojas M, Chiluiza K, Valcke M, Bolaños-Mendoza C. How gamification boosts learning in STEM higher education: A mixed methods study. Education Sciences, 2025. Doi: <https://doi.org/10.3390/educsci12080533>
79. Ortiz-Rojas M, Chiluiza K, Valcke M, *et al.* How gamification boosts learning in STEM higher education: A mixed methods study. Journal of STEM Education. Springer, 2025. Doi: <https://doi.org/10.1186/s40594-024-00521-3>
80. Özhan ŞÇ, Kocadere SA. The effects of flow, emotional engagement, and motivation on success in a gamified online learning environment. Journal of Educational Computing Research. SAGE, 2020. Doi: <https://doi.org/10.1177/0735633118823159>
81. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, *et al.* The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ. 2021; 372:n71. Doi: <https://doi.org/10.1136/bmj.n71>
82. Pangelinan JR, Aso AR, Ndengo VP. Integrating gamification into middle school mathematics curriculum: Game-based learning approach in Namibia. International Innovatus U, 2022. Doi: <https://doi.org/10.18775/ijonm.2757-0509.2020.24>
83. Panskyi T, Rowińska Z. A holistic digital game-based learning approach to out-of-school primary programming education. Education Sciences, 2021. Doi: <https://doi.org/10.3390/educsci12080535>
84. Pehlivan F, Arabacioglu T. The effect of gamification on math achievement, motivation, and learning strategies in flipped classrooms. International Australasian, 2023. Doi: <https://doi.org/10.7575/aiac.ijels.v11n.4p.309>
85. Peng M, *et al.* Gamification enhances student intrinsic motivation, perceptions of autonomy and relatedness, but minimal impact on competency: A meta-analysis and systematic review. Educational Technology Research and Development, 2023. <https://link.springer.com/article/10.1007/s11423-023-10337-7>
86. Pineda-Martínez M, Llanos-Ruiz D, Puente-Torre P, García-Delgado MÁ. Impact of video games, gamification, and game-based learning on sustainability

- education in higher education. *Education Sciences*, 2023. Doi: <https://doi.org/10.3390/educsci12080523>
87. Pradhan S, Gurung A, Ottmar E. Gamification and Deadending: Unpacking performance impacts in algebraic learning. *Proceedings of the 14th Learning at Scale Conference*. ACM, 2024. Doi: <https://doi.org/10.1145/3636555.3636929>
 88. Puspitasari I, Arifin S. Implementation of gamification on learning motivation: A meta-analysis study. *International Journal*, 2023. Doi: <https://doi.org/10.52155/ijpsat.v44.1.5996>
 89. Ragni B, Toto GA, Di Furia M, Lavanga A, Limone P. The use of digital game-based learning (DGBL) in teachers' training: A scoping review. *Education Sciences*, 2023. Doi: <https://doi.org/10.3390/educsci12080521>
 90. Ratinho E, Martins C. The role of gamified learning strategies in student's motivation in high school and higher education: A systematic review. *Heliyon*, 2023. Doi: <https://doi.org/10.1016/j.heliyon.2023.e13033>
 91. Ren J, Xu W, Liu Z. The impact of educational games on learning outcomes. *Education Sciences*, 2024. Doi: <https://doi.org/10.3390/educsci12080529>
 92. Reyes J, Arandilla R. The impact of Quizizz and Kahoot! on Filipino secondary students' engagement in Cebu City. *Philippine Journal of Educational Technology*. 2023; 12(1):33-48. <https://ejournals.ph/>
 93. Reyes M, Tan J. Dynamics of gamification in tertiary mathematics education in the Philippines: A systematic review. *International Journal of Education and Applied Innovation*. 2024; 10(1):33-48. <https://ijeais.org/wp-content/uploads/2024/5/IJAPR240509.pdf>
 94. Rodrigues L, Pereira FD, Toda AM, Palomino PT, Pessoa M, De Carvalho LSG, *et al.* Gamification suffers from the novelty effect but benefits from the familiarization effect: Findings from a longitudinal study. *International Journal of Educational Technology in Higher Education*, 2022. Doi: <https://doi.org/10.1186/s41239-021-00314-6>
 95. Rosil LL, Elpidang EM. Effectiveness of Math Legend (ML) game-based approach in teaching mathematics. *International Journal of Research and Innovation in Social Science (IJRISS)*. 2025; 9(4):2881-2889. Doi: <https://doi.org/10.47772/IJRISS.2025.90400214>
 96. Sánchez Castillo V, Gómez Cano CA. Gamification and motivation: An analysis of its impact on corporate learning. *Gamificat AG Editor*, 2024. Doi: <https://doi.org/10.56294/pr202426>
 97. Santos M, Villanueva K. Math anxiety reduction through gamified instruction in Cebu City schools. *Journal of Philippine Educational Psychology*. 2023; 6(1):19-34. <https://ejournals.ph/>
 98. Saxena M, Mishra DK. Gamification and Gen Z in higher education. *International Journal of Information and Communication Technology Education*, 2021. Doi: <https://doi.org/10.4018/ijicte.20211001.0a9>
 99. Setiawan F, Phillipson SN. E-learning and mathematics achievement: A review of research trends and findings. *Education and Information Technologies*. 2022; 27:947-969. Doi: <https://doi.org/10.1007/s10639-021-10747-2>
 100. Simplilearn. Descriptive vs. inferential statistics. *Simplilearn*, May 7, 2024. <https://www.simplilearn.com/difference-between-descriptive-inferential-statistics-article>
 101. Singh J. Critical appraisal skills programme. *Journal of Pharmacology & Pharmacotherapeutics*. 2022; 13(2):94-96. Doi: https://doi.org/10.4103/jpp.jpp_68_22
 102. Sousa-Vieira ME, López-Ardao JC, Fernández-Veiga M, Rodríguez-Rubio RF. Study of the impact of social learning and gamification methodologies on learning results in higher education. *Education Sciences*, 2022. Doi: <https://doi.org/10.3390/educsci12080519>
 103. Sousa-Vieira ME, López-Ardao JC, *et al.* Study of the impact of social learning and gamification methodologies on learning results in higher education. *Computer Applications in Engineering Education*. Wiley, 2023. Doi: <https://doi.org/10.1002/cae.22575>
 104. StackExchange. Converting between confidence interval and standard error. *Cross Validated (Stack Exchange)*, 2021. <https://stats.stackexchange.com/questions/512789/converting-between-confidence-interval-and-standard-error>
 105. Su Y, Backlund P, Engström H. Comprehensive review and classification of game analytics. *Frontiers in Psychology*, 2020. Doi: <https://doi.org/10.3389/fpsyg.2021.642720>
 106. Sulpico CQ, Lapis RJT, Paner NRT, Sagaral MIV, Tura JL, Vismanos MH, *et al.* Improving Grade 7 mathematics outcomes through game-based learning: An action research study. *The Normal Lights*, 2024. <https://www.pnuresearchportal.org/ejournal/index.php/normalights/article/view/3132>
 107. Tan CT, Devilly OZ, Lim SM, Divo B, Kok XFK. The effect of gamification mechanics on user experiences of AdventureLEARN: A self-driven learning platform. *Proceedings of the ACM Conference on Learning at Scale*. ACM, 2023. Doi: <https://doi.org/10.1145/3611062>
 108. Temel T, Cesur K. The effect of gamification with Web 2.0 tools on EFL learners' motivation and academic achievement in online learning environments. *SAGE Open*. SAGE, 2024. Doi: <https://doi.org/10.1177/21582440241247928>
 109. Vanacore K, Sales A, Liu A, Ottmar E. Benefit of gamification for persistent learners: Propensity to replay problems moderates algebra-game effectiveness. *Proceedings of the ACM Conference on Learning at Scale*. ACM, 2023. Doi: <https://doi.org/10.1145/3573051.3593395>
 110. Vankuš P. Influence of game-based learning in mathematics education on students' affective domain: A systematic review. *Mathematics*, MDPI AG, 2021. Doi: <https://doi.org/10.3390/math9090986>
 111. Vergara D, Antón-Sancho Á, *et al.* Player profiles for game-based applications in engineering education. *Computer Applications in Engineering Education*. Wiley, 2024. Doi: <https://doi.org/10.1002/cae.22576>
 112. Villamor D, Carreon A. Emotional engagement in gamified math lessons among Filipino students. *Philippine Journal of Educational Research*. 2023; 9(2):44-59. <https://ejournals.ph/>
 113. Vrcelj A, Hoić-Božić N, Holenko Dlab M. Use of gamification in primary and secondary education: A systematic literature review. *Education Sciences*, 2022. Doi: <https://doi.org/10.3390/educsci12080528>
 114. Wang LH, Chen B, Hwang GJ, Guan JQ. Effects of digital game-based STEM education on students' learning achievement: A meta-analysis. *Journal of*

- STEM Education. Springer, 2022. Doi: <https://doi.org/10.1186/s40594-022-00344-0>
115. Wang T, Chen Y, Li J. Exploring the impact of digital learning tools on mathematics achievement: A meta-analytic review. *Journal of Computer Assisted Learning*. 2022; 38(5):1258-1273. Doi: <https://doi.org/10.1111/jcal.12691>
 116. Yanurito WN, Hastinasyah PD. Gamification: Quizizz in mathematical game learning for secondary students. *International Universitas*, 2023. Doi: <https://doi.org/10.24114/jpe.v5i2.6528>
 117. Yiğ KG, Sezgin S. An exploratory holistic analysis of digital gamification in mathematics education. *Journal of Educational Technology and Online Learning*. Dergipark, 2021. Doi: <https://doi.org/10.31681/jetol.888096>
 118. Yoo JL, Pyon H, Woo J. Digital twin for math education: A study on the utilization of games and gamification for university mathematics education. *Electronic MDPI AG*, 2023. Doi: <https://doi.org/10.3390/electronics12135327>
 119. Zaric N, Lukarov V, Schröder U. A fundamental study for gamification design: Exploring learning tendencies' effects. *International Serious Games*, 2020. Doi: <https://doi.org/10.17083/ijsg.v7i4.356>
 120. Zeng J, Sun D, Looi CK, *et al.* Exploring the impact of gamification on students' academic performance: A comprehensive meta-analysis of studies from the year 2008 to 2023. *British Journal of Educational Technology*. Wiley, 2024. Doi: <https://doi.org/10.1111/bjet.13471>
 121. Zeng J, Sun D, Looi C-K. Exploring the impact of gamification on students' academic performance: A comprehensive meta-analysis of studies from the year 2008 to 2023. *British Journal of Educational Technology*. 2024; 55(6):2478-2502. Doi: <https://doi.org/10.1111/bjet.13471>
 122. Zhang Q, Yu L, Yu Z. A content analysis and meta-analysis on the effects of Classcraft on gamification learning experiences in terms of learning achievement and motivation. *Education Research International*. Wiley, 2021. Doi: <https://doi.org/10.1155/2021/9429112>
 123. Zhang Q, Yu Z. Meta-analysis on investigating and comparing the effects on learning achievement and motivation for gamification and game-based learning. *Education* Wiley, 2022. Doi: <https://doi.org/10.1155/2022/1519880>
 124. Zhang Z, Huang X. Exploring the impact of the adaptive gamified assessment on learners in blended learning. *Education and Information Technologies*. Springer, 2024. Doi: <https://doi.org/10.1007/s10639-024-12708-w>
 125. Zhang Q, Yu L, Yu Z. A content analysis and meta-analysis on the effects of Classcraft on gamification learning experiences in terms of learning achievement and motivation. *Education Research International*. Wiley, 2021. Doi: <https://doi.org/10.1155/2021/9429112>
 126. Zhang Q, Yu Z. Meta-analysis on investigating and comparing the effects on learning achievement and motivation for gamification and game-based learning. *Education* Wiley, 2022. Doi: <https://doi.org/10.1155/2022/1519880>
 127. Zhang Z, Huang X. Exploring the impact of the adaptive gamified assessment on learners in blended learning. *Education and Information Technologies*. Springer, 2024. Doi: <https://doi.org/10.1007/s10639-024-12708-w>