Teaching Mathematics Using Gamification to Enhance Elementary Students' Learning Outcomes

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Abstract

The study aimed to: (1) design a gamified mathematics lesson plan to enhance elementary students' learning outcomes, (2) to compare the results of learning outcomes before and after the intervention, and (3) to examine student satisfaction with the gamified learning experience. This study investigated the effectiveness of gamified instruction in enhancing mathematics learning outcomes and student engagement among Prathomsuksa 5 students at Pattanawit School, School of Intelligent Skill (SIS). Using a pre-experimental one-group pretest-posttest design, the six-week intervention involved 35 participants. The instruments included two researcher-developed unit-based mathematics tests (pre- and post-tests) to assess academic performance and a 20-item Likert-scale student satisfaction survey to measure perceptions of the gamified experience. Classroom observation checklists and Quizizz usage reports were also utilized to monitor engagement and participation. Data were analysed using mean, standard deviation, and paired-sample t-tests. The results of this study revealed that: (1) the design of the gamification mathematics lesson plan incorporates game-based elements such as avatars, experience points (XP), badges, leaderboards, and Quizizz-based assessments. Students also created personalized avatars, which were digitized using Canva and AI image generators to provide a more immersive and motivating learning experience. (2) Academic performance was assessed through unit-based pre- and post-tests, with significant gains observed in both Unit 1 ($M = 12.94$, $SD = 3.79$) and Unit 2 ($M = 16.06$, $SD = 2.01$), with p-values $< .001$. Quizizz usage data showed increased accuracy and participation, while classroom observations confirmed improved motivation and reduced mathematics anxiety. (3) A 20-item student satisfaction survey yielded a mean score of 3.88 ($SD = 1.06$), indicating positive perceptions of the gamified approach. Some neutral responses to competitive elements suggested the importance of maintaining balance in game design.

Keywords: Gamification, Elementary Mathematics, Learning Outcomes, Student Satisfaction, Quizizz, Motivation

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Introduction

Mathematics is the exact field of science that promotes and facilitates critical thinking among its learners and has made an immense and fundamental impact on the progress and development of science and technology. Today, however, students might have a different perspective on mathematics. As Solekhah et al. (2023) state, many of their Indonesian students consider mathematics a subject that is uninteresting and only confuses them. While some find it boring, others see it as a worthwhile but still challenging subject. This perspective is a global phenomenon, as students around the world often share this view. In Thailand, student performance in mathematics reflects this struggle. The 2022 PISA results revealed that Thai 15-year-old students performed significantly below the OECD average in mathematics, ranking 58th out of 81 participating regions. The average mathematics score in Thailand was 394, considerably lower than the OECD's 472 average. In addition, only 32% of Thai students achieved at least a level 2 proficiency in mathematics compared to the OECD's average of 69%. (OECD, 2023). According to Kawikitmanee (2024), long term absenteeism and lower socio-economic status were the factors contributing to the underperformance.

Language barriers and low student motivation also seem to be contributing factors to this poor performance. Due to a lack of perceived relevance to their daily lives, many Thai students find it difficult to relate to mathematical concepts. These difficulties are worsened for students learning a second language since they have to tackle both the subject matter and new linguistic complexities (Durado and Opina, 2025). Traditional teaching methods, which usually place an emphasis on rote memorization and repetition, frequently fall short in terms of engaging students or accommodating different learning styles. Thus, it is evident that both the way mathematics is taught and how students view it need to change.

One response gaining traction is *gamification*. This is the integration of game-based elements into educational settings. The growing popularity of gamification stems from the belief in its potential to foster motivation, behavioural changes, friendly competition, and collaboration in different contexts (Dichev and Dicheva, 2017). By incorporating elements such as rewards, progress tracking, and immediate feedback, students become more willing to engage with challenging problems. According to Alexander and Reyes-Chua (2024), students in gamified mathematics lessons showed greater determination and improved outcomes compared to those in traditional settings. Unlike rote memorization, which often leads to disengagement, gamification allows students to explore mathematical concepts through play, competition, and collaboration, ultimately helping them build confidence and a positive attitude toward the subject. As a foreign lecturer teaching elementary mathematics to students who are not allowed to use mobile phones or digital devices during class, applying a gamified approach poses challenges. However, it also offers an opportunity to reach learners who might benefit most from alternative strategies.

Considering these limitations, this study explores the potential of the Quizizz app, in paper mode, as a gamified platform to improve mathematics instruction for fifth-grade ESL students. Helping students at this level make the mental and emotional transition to more complex ideas, such as fractions and problem-solving, can be challenging. Especially in schools with a wide range of language abilities, gamification can provide this kind of support. Personalized pace, visual signals, and realistic, attainable objectives all contribute to a more positive learning environment. The role of the teacher, as both a facilitator and an architect of learning, is crucial to this endeavour. By focusing on both student outcomes and teacher implementation, this research aims to assess the long-term potential of gamification in mathematics and its ability to close the gap between engagement and academic achievement.

Research Objective

1. To design a gamified mathematics lesson plan to enhance elementary students' learning outcomes.
2. To compare the results of learning outcomes before and after the intervention.
3. To examine student satisfaction with the gamified learning experience.

Conceptual Framework

This study adopts a conceptual model to investigate how gamification influences mathematics learning and student satisfaction. The framework emphasizes that game elements affect both cognitive performance and emotional engagement in primary-level instruction.

Gamification draws on two forms of motivation: intrinsic, through the enjoyment of solving problems, and extrinsic, through rewards and recognition. Research shows that when learning is enjoyable, students are more engaged, retain knowledge more effectively, and develop more positive attitudes toward mathematics.

Common features include points for correct answers, badges for achievements, progressive levels and challenges, real-time feedback, and peer-based competition or collaboration (Majuri et al., 2018). The model proposes that integrating these mechanics into mathematics teaching enhances engagement, supports mastery, and ultimately improves both achievement and satisfaction.

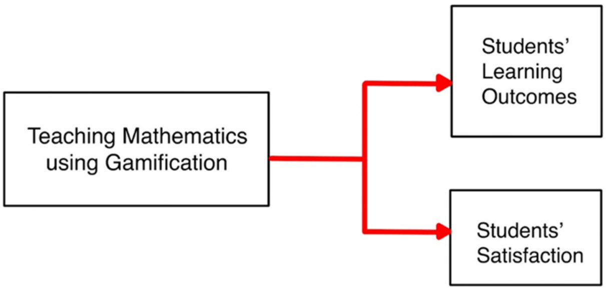

Figure 1 Conceptual Framework

Literature Review

The idea of gamification is often credited to game developer Nick Pelling in the early 2000s, though his work was initially directed at commercial use. Interest in education soon followed, but the foundations reach back further. Behaviourist psychology, especially B.F. Skinner's work on reinforcement and conditioning, anticipated many of the principles now central to gamified instruction. In The Behavior of Organisms (1938) and later *Science and Human Behavior* (1965), Skinner showed how rewards, structured progression, and timely feedback could shape learning behaviour. Although not described as "games," these strategies mirror the points, feedback loops, and progression systems found in today's classrooms. Building on this foundation, modern gamification in education has evolved into varied approaches, from basic point-and-badge systems to fully immersive, game-like environments.

In primary education, where motivation and engagement are critical for successful learning, gamification has gained a strong foothold in transforming traditional lessons into more interactive and enjoyable experiences. This approach has particular significance in mathematics, which is widely regarded as a foundation for logical reasoning and problem-solving in early education (Xayrullayevna, 2024). Effective mathematics instruction at this level depends on three key components: conceptual understanding, procedural fluency, and strategic competence (Yeh et al., 2019; Findell et al., 2001). Understanding concepts means seeing mathematics as parts of a bigger picture instead of just facts on their own. Procedural fluency is the ability to do mathematics operations correctly and quickly while still understanding the concepts behind them. Strategic competence focuses on the capacity to articulate and resolve challenges, especially those necessitating thinking and planning.

The gamification of learning aligns well with constructivist theory, which emphasizes hands-on activity, social interaction, and engagement with one's environment. Gamified instruction blends classroom teaching with game-based experiences, creating a learning environment that supports a range of learning styles and abilities. Hui et al. (2023) describe three levels of gamification: shallow gamification, which relies on simple features such as points, badges, and leaderboards; deep gamification, which adds narratives, challenges, and meaningful choices; and total gamification, in which the entire learning process is embedded in an immersive game-based system.

Gamification can also play a role in reducing mathematics anxiety, which is common among elementary learners. By presenting mathematics in a playful, low-stakes way, it encourages students to keep trying and take risks. Still, its effectiveness relies on thoughtful design. According to Yan (2023), Lo (2021), and Debrenti (2024), instead, personalised features such as avatars, badges, and leaderboards are consistently identified as effective motivators. Sailer et al. (2017) found that these elements enhanced competence and task meaningfulness. Similarly, Khaldi et al. (2023) reported that badges sustain long-term motivation by rewarding persistence, while Toda et al. (2019) showed that well-designed leaderboards can create both competition and collaboration in supportive ways.

Taken together, research suggests that when thoughtfully implemented, avatars, badges, and leaderboards can enrich the learning experience, increase student motivation, and foster deeper connections with mathematical content. Building on these insights, the present study incorporated these elements into its gamified mathematics intervention.

Research Methodology

Research Design

This study uses a Pre-Experimental Design using the One-Group Pretest-Posttest Design technique which measures outcomes before and after an intervention without a control group (Cohen et al., 2002). The design is illustrated in Table 1.

Table 1: One-Group Pretest-Posttest Design

<table>
<tr><th>Group</th><th>Pre-test</th><th>Intervention</th><th>Post-test</th></tr>
<tr><td rowspan="2">E
Experimental</td><td>O_1
Pre-test</td><td rowspan="2">X
Gamified mathematics instruction</td><td>O_2
Post-test</td></tr>
<tr><td>O_3
Pre-test</td><td>O_4
Post-test</td></tr>
</table>

Population and Sample

The population consists of 308 elementary students, representing 14 classes (Prathomsuksa 1-6) at Pattanawit School, School of Intelligent Skill (SIS) (Pattanawit School Registrar Office, 2025). The sample will include 35 Prathomsuksa 5 students, comprising two sections. Cluster random sampling was employed to ensure consistency in academic background and learning environment.

Research Instrument

Three validated instruments were used: a standardized mathematics pre- and post-test, a 20-item Likert scale student satisfaction survey, and a gamification-based mathematics lesson plan as follows:

1. Pre-Test and Post-Test: Student performance was measured with a 20-question multiple-choice test based on the national curriculum. Each correct answer earned one point, for a total possible score of 20. To check content validity, three subject matter experts assessed the items using the Item-Objective Congruence (IOC) method (Rovinelli and Hambleton, 1976). The average IOC score was 0.83 for Unit 1 and 0.85 for Unit 2, both well above the 0.5 threshold. Most questions received full agreement from all reviewers. Minor changes were made to improve clarity and to adjust difficulty for students with varying levels of prior knowledge.

2. Students' Satisfaction Survey Questionnaire: Student perceptions of the gamified learning experience were measured using a 20-item, 5-point Likert scale survey covering enjoyment, motivation, engagement, and willingness to continue learning through gamification. The survey also addressed specific game components such as avatars, points, badges, and leaderboards. An initial 30-item version was reviewed by three experts using the IOC method. Items scoring below 0.5 were revised or removed, resulting in the final 20-item instrument with an average IOC score of 0.85.

3. Gamification Lesson Plan: The lesson plan, consisting of 18 lessons (15 instructional hours), was designed to introduce Prathomsuksa 5 students to gamification in mathematics. Lessons specified objectives, interactive activities, and a structured rewards system, with Quizizz paper mode as the core game mechanic. Three education and instructional design experts validated the plan using a 5-point Likert scale, resulting in a mean score of 4.68 (SD = 0.40), indicating high quality. Recommendations led to the inclusion of a teacher's guide, expanded assessment strategies, and diversified game platforms.

4. Integration of Avatars and Badges

To personalize the experience, students first hand-drew avatars representing themselves. These drawings were digitized using Canva and AI image generation tools, ensuring compatibility with digital platforms while preserving creativity. Each student profile displayed their avatar, accumulated badges, and completed lesson quests with star ratings.

Figure 2 Hand-drawn by a student

Figure 3 Digitized version

Figure 4 Avatar evolution from Level 1 to Level 3

Figure 5 The student profile: 1. Their Avatars 2. Player Number 3. Quests 4. Badges earned

Avatars progressed through three levels as students completed tasks and demonstrated mastery. Visual upgrades (e.g., accessories, outfits) symbolized academic growth and accomplishments. Alongside avatars, badges were awarded for specific actions and achievements. A three-tier, star-based badge system was implemented, and achievements were announced weekly.

Table 2 Star-based performance and badges.

	**3 Stars**: All 10 questions correct **2 Stars**: 5–9 questions correct **1 Star**: Fewer than 5 questions correct		**Smart Cookie Badge (3 Stars):** Recognized top performers who showed both accuracy and effort.
	**Good Job Badge (2 Stars):** Celebrated steady progress and consistent participation.		***Teamwork Badge****: Given to students who actively contributed to the group problem-solving.*

Student scores from weekly Quizizz paper-mode activities were ranked using Keepthescore.com, with results displayed on a classroom leaderboard. To maintain a supportive atmosphere, leaderboards emphasized effort, persistence, and improvement, rather than only high scores.

Data Collection

The study was carried out over seven weeks in three main phases:

Table 3 Research Implementation Steps

Phase	Research Implementation Steps	Outcomes
1. Design Mathematics Gamification (Objective 1)	1.1 Study related concepts, documents, theories, and research to teach mathematics using gamification.	
	1.2 Create and develop mathematics lesson plans using gamification	Lesson plans created
	1.2.1 Validate lesson plans through expert review (5-point Likert scale)	Validated lesson plans
	1.3 Create pre-test and post-test for each unit	Test items created
	1.3.1 Validate test items (Item-Objective Congruence method: +1, 0, -1)	Validated Test items
	1.4 Create students' satisfaction questionnaire	Survey developed
	1.4.1 Validate satisfaction survey (IOC method)	Validated survey
	1.5 Prepare for implementation: 18 hours of instruction	Instructional timeline finalized
2. Implementation of gamification (Objective 1)	2.1 Administer Pre-test followed by teaching Unit 1: Fractions (Comparison, Ordering, Addition, Subtraction)	Baseline performance
	2.2 Conduct step by step in teaching mathematics by using Gamification	Performance data
	2.2.1 Teaching Unit 1: Fractions using gamified lesson	Gamified instruction
	2.2.2 Post-test after completing Unit: 1 Fractions	Performance data
	2.3 Pre-test follow by teaching Unit 2: Fractions (Multiplication)	Baseline performance
	2.3.1 Teaching Unit 2: Fractions using Gamification	Gamified instruction
	2.3.2 Post-test after completing Unit: 2 Fractions	Performance data
3. Evaluation Phase (Objective 2 and 3)	3.1 Analyse pre-test and post-test results using mean and standard deviation (SD)	Performance comparison (Pre-Post results)
	3.2 Compare results before and after using t-test for dependent samples	Statistical analysis
	3.3 Administer Students' satisfaction questionnaire	Satisfaction data
	3.4 Analyse students' satisfaction results using mean and standard deviation (SD)	

Data Analysis

1. Descriptive statistics (mean, standard deviation) summarized performance data

2. Paired-sample t-tests compared pre- and post-test scores for statistical significance Satisfaction Survey Analysis

3. Mean scores were calculated and interpreted to assess student engagement and attitudes

Findings

This section presents the key findings from the pretest-posttest assessments, gamification platform data, and student satisfaction surveys.

1. The Results of the Designing a Gamified Mathematics Lesson Plan

A gamified mathematics lesson plan was developed and validated by three experts using a 20-item Likert scale evaluation tool. The evaluation addressed: (1) content alignment, (2) instructional design, (3) gamification components, (4) student engagement, and (5) assessment strategy.

Expert validation confirmed the educational quality and efficacy of the created gamification intervention. The lesson plan received a mean score of 4.68 (SD = 0.40), with high praise for its clear objectives and integrated gamified elements like levels, rewards, and avatars. Suggestions for improvement included adding a teacher's guide, providing more flexible formative assessment options, and incorporating a wider range of gamified activities beyond Quizizz. These findings confirm the lesson plan's validity and potential to positively impact learning outcomes in elementary mathematics education.

2. The Results of the Learning Outcomes Comparison

To evaluate the effectiveness of the gamified intervention, a paired-samples t-test was conducted on student pre- and post-test scores for two units.

Table 4 Unit 1: Addition and Subtraction of Fractions

Unit 1	Mean	SD	t	p-value
Pre-test	9.86	4.09	9.69**	0.000
Post-test	12.94	3.79		

$t(34) = 9.69$, $p \leq 0.001$, ** significant at a level of .01

Table 4 show a statistically significant improvement in student scores from the pre-test to the post-test of Unit 1, $t(34)=9.69, p<0.001$. This indicates that the gamified approach effectively improved learning outcomes for this unit.

Table 5 Unit 2: Multiplication of Fractions.

Unit 2	Mean	SD	t	p-value
Pre-test	10.49	2.58	14.72**	0.000
Post-test	16.06	2.01		

$t(34) = 9.69$, $p \leq 0.001$, ** significant at a level of .01

The Table 5 for Unit 2, the mean score also increased significantly from the pre-test to the post-test, $t(34)=14.72$, $p<0.001$. This substantial gain suggests an even stronger effect of the intervention in this unit.

These findings support the hypothesis that gamified instruction significantly enhances the mathematical performance of elementary learners.

3. The Results of the Student Satisfaction

A 20-item Likert-scale survey (1 = Strongly Disagree to 5 = Strongly Agree) was administered to all 35 participating students to evaluate their satisfaction with the gamified mathematics program. In table 6., the overall average score was 3.88, indicating a generally positive response to the gamification approach.

Specifically, students reported high satisfaction with the use of avatars and badges and expressed increased motivation to complete tasks. They also showed a preference for the gamified lessons over traditional teaching methods.

Table 6 The results from the satisfaction survey

	Item	Mean	SD	Level
1	I enjoyed the process of creating my avatar and seeing it become a digital version.	4.06	0.97	High
2	I try to study better in mathematics because I want to improve my avatar.	3.89	0.96	High
3	Using an avatar makes mathematics more exciting to learn.	3.91	1.09	High
4	Experience points motivate me to complete mathematics tasks.	3.91	1.09	High
5	I learn more when experience points are part of mathematics activities.	4.03	1.10	High
6	I want to reach a new level before others.	3.00	1.31	Moderate
7	I feel proud to show others the badges I've earned.	3.60	1.14	High
8	Collecting badges gives me a sense of accomplishment.	4.06	0.97	High
9	I try to do my best in mathematics to earn new badges.	3.89	1.30	High

Table 6 (continued)

	Item	Mean	SD	Level
10	Competing with my classmates on the leaderboard motivates me to improve.	3.57	0.92	High
11	I feel great when I see myself move up on the leaderboard.	4.37	0.88	High
12	The leaderboard shows me how much I need to improve.	4.03	1.10	High
13	Interactive videos in Quizizz make me understand mathematics better.	4.17	1.01	High
14	Paper mode in Quizizz helps me answer more carefully.	4.83	1.12	Very High
15	I enjoy mathematics more because of the fun activities in Quizizz.	4.06	1.03	High
16	Gamification helps me understand mathematics better than traditional methods.	4.09	1.04	High
17	I feel less nervous about making mistakes during gamified activities.	3.60	0.88	High
18	I pay more attention in gamified mathematics lessons.	3.83	1.01	High
19	I feel more confident learning mathematics with points, badges, and avatars.	3.60	1.26	High
20	I want gamified mathematics to be part of our regular school lessons.	4.06	1.06	High
Average score of the Satisfaction Survey		3.88	1.06	High

Table 7 shows the Mean Range for the Satisfaction Survey

Mean Range	Description	Interpretation
4.50 – 5.00	Very High	Indicates that students possess very high level of satisfaction with gamification mathematics
3.50 – 4.49	High	Indicates that students possess high level of satisfaction with gamification mathematics
2.50 – 3.49	Moderate	Indicates that students possess moderate level of satisfaction with gamification mathematics
1.50 – 2.49	Low	Indicates that students possess low level of satisfaction with gamification mathematics
1.00 – 1.49	Very Low	Indicates that students possess very low level of satisfaction with gamification mathematics

Analysis of individual items from the student satisfaction survey revealed specific features that were highly rated. Students reported the most satisfaction with "paper mode" in Quizizz (M = 4.83), followed by seeing themselves move up on the leaderboard (M = 4.37), and the use of interactive videos to aid understanding (*M* = 4.17). However, responses to competitive elements were mixed. While leaderboards were a motivating factor for many (*M* = 4.37 for Item 11 and *M* = 3.57 for Item 10), the desire to "reach a new level before others" (*M* = 3.00) received a neutral score, suggesting that this particular competitive mechanic did not appeal to all students. These varied responses highlight the need for a balanced approach to game mechanics to ensure the intervention remains inclusive and engaging for a diverse group of learners.

Discussion

The findings from this pre-experimental, one-group pretest-posttest study confirm that a gamified lesson plan is an effective tool for enhancing both student engagement and academic achievement in elementary mathematics. The gamified lesson plan, which integrated avatars, badges, leaderboards, and digital quizzes using the Quizizz app, was positively evaluated by experts for its instructional quality and ability to enhance student engagement across multiple dimensions.

The study provides strong evidence of a link between gamification and improved academic outcomes. A statistically significant increase in mathematics achievement was observed, with post-test scores rising for both Unit 1 ($t(34)=9.69$, $p<0.001$) and Unit 2 ($t(34)=14.72$, $p<0.001$). This stronger gain in Unit 2 suggests that students' familiarity with the gamified format and the cumulative effect of motivational elements likely contributed to enhanced learning and retention. This evidence aligns with prior research by Kapp (2012) and Rachmadi et al. (2025), who found that purposeful gamification effectively fosters active learning and student motivation.

The success of the intervention was further supported by high student satisfaction. Students particularly enjoyed the customizable avatars and found interactive videos and digital quizzes to be highly engaging. However, the mixed responses to competitive game mechanics like peer-levelling systems highlight a key finding also noted by Hanus and Fox (2015), overly competitive dynamics can have varied effects. This suggests that a balanced approach, mixing competition with collaborative elements, is important for ensuring inclusivity and maintaining engagement for all students.

The study's success in enhancing student achievement, especially the significant improvements in Unit 2, corroborates the idea that gamification not only enhances initial engagement but also facilitates conceptual understanding and information retention over time, a fundamental objective in mathematics education as highlighted by Findell et al. (2001).

Suggestion

1. Suggestion for Research Utilization

The findings carry several practical implications for instructional design. First, gamified lesson plans can make abstract concepts tangible and easier to grasp. For example, instead of simply presenting fractions in symbolic form (e.g., ½, ¼, ¾), a teacher could design an activity where students collect pizza slices to complete a whole. Reaching the next level requires combining the correct fractions, thereby turning an abstract concept into a visible, interactive goal that sustains motivation.

Second, progression systems provide personalized and immediate feedback that supports continuous learning. In a gamified setup, students might earn 10 XP for a correct solution and 5 XP for a partially correct one. This ensures that effort and partial understanding are still acknowledged while encouraging students to try again for mastery. Unlike traditional feedback that often comes after a test or homework review, this system offers real-time correction and reinforces persistence.

Third, gamification enhances inclusivity, particularly for English as a Second Language (ESL) learners. Visual progress markers such as avatars levelling up or scores displayed on a leaderboard, shows achievement without relying heavily on language. Similarly, animated videos showing step-by-step processes (e.g., shading grids when multiplying fractions) help students focus on mathematical reasoning rather than struggling with language barriers. The visual and interactive elements are particularly beneficial for ESL learners, instead of only reading and hearing instructions, which might be hard, these children can learn by seeing, hearing, and touching the content.

By incorporating these practices into instructional design, teachers can create mathematics classrooms that are not only more engaging but also more accessible, equitable, and responsive to students' individual needs.

2. Suggestion for Future Research

While the results are promising, several limitations should be acknowledged. First, the study employed a pre-experimental one-group pretest–posttest design, which lacks a control group. As a result, improvements in student achievement may partly reflect external factors such as increased teacher attention or prior exposure to mathematics concepts. Future studies should adopt quasi-experimental or randomized controlled trials to better establish causal effects of gamification.

Second, the sample size (n = 35) and single-school context limit generalizability. Gamification may function differently in larger classes, in schools with fewer digital resources, or in contexts with varying levels of student familiarity with technology. Replication in diverse settings and grade levels would test whether gamification is equally effective across broader populations.

Third, the intervention was conducted over a short seven-week period, which restricted analysis of long-term retention or sustained motivation. Gamification often shows a strong novelty effect; therefore, longitudinal studies spanning a semester or academic year are needed to determine whether the motivational gains observed persist once the novelty wears off.

Fourth, the study emphasized competitive mechanics (leaderboards, XP, badges), while collaborative mechanics such as team quests, peer mentoring, or group challenges were underexplored. Given mixed student responses to leaderboards, future research should compare competitive, collaborative, and hybrid gamification models to determine which best sustain engagement without discouraging lower-performing learners.

Finally, although the intervention supported ESL learners through visuals and avatars, the study did not systematically examine language-related learning outcomes. Future research could specifically investigate whether gamification improves mathematics comprehension and participation for students with limited language proficiency.

References

Alexander, J. P., Reyes-Chua, E., and Publishing, E. H. B. (2024). Exploring the Influence of Gamification on Student Engagement and Learning Outcomes in Mathematics Classrooms for Grades K-12. *Asian Research Journal of Education*, *1*(1), 2–22.

Cohen, L., Manion, L., and Morrison, K. (2002). *Research methods in education*. Routledge.

Debrenti, E. (2024, March). Game-Based Learning experiences in primary mathematics education. *Frontiers in Education, 9*, 1-8. https://doi.org/10.3389/feduc.2024.1331312

Dichev, C., and Dicheva, D. (2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International journal of educational technology in higher education*, *14*(9), 1-36. https://doi.org/10.1186/s41239-017-0042-5

Durado, J., Opina, M., (2025). Upper-Primary Thai Students’ Engagement, English Proficiency, and Mathematics Performance. *Psychology and Education: A Multidisciplinary Journal, 36*(8), 906-920. https://doi.org/10.70838/pemj.360806

Findell, B., Swafford, J., and Kilpatrick, J. (Eds.). (2001). *Adding it up: Helping children learn mathematics*. National Academies Press.

Hanus, M. D., and Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers and Education, 80,* 152–161.

Hui, H. B., and Mahmud, M. S. (2023). Influence of game-based learning in mathematics education on the students' cognitive and affective domain: A systematic review. *Frontiers in Psychology*, *14*, 1105806.

Kapp, K. M. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. Pfeiffer.

Kawikitmanee, K. (2024, March 26). Lessons from PISA 2022: What Characterizes a Resilient Education System?. *Equitable Education Research Institute (EEFI).* [Online]. Retrieved from: https://research.eef.or.th/lessons-from-pisa-2022-what-characterizes-a-resilient-educaion-system/

Khaldi, A., Bouzidi, R., and Nader, F. (2023). Gamification of e-learning in higher education: a systematic literature review. *Smart Learning Environments*, *10*(10), 1-31.

Lo, H. M. (2021). *Instructional Strategies for Game-Based Learning: Use Technology in the Elementary Mathematics Classroom*. In: Bakan, U and Berkeley, S (ed.), Gamification and Social Networks in Education, MacroWorld Pub. Ltd.

Majuri, J., Koivisto, J., and Hamari, J. (2018). Gamification of education and learning: A review of empirical literature. *GamiFIN*, 11-19.

Organisation for Economic Co-operation and Development. (2023). *PISA 2022 Results (Volume I and II): Country Notes: Thailand*. OECD Publishing.

Rachmadi, P., Situmorang, R., and Sukardjo, M. (2025). Highten Discrete Mathematics Learning Through Gamified: A Sustainable Development Goals (SDG) Perspective. *Journal of Lifestyle and SDGs Review*, *5*(2), e03911-e03911.

Rovinelli, R. J., and Hambleton, R. K. (1976). On the use of content specialists in the assessment of criterion-referenced test item validity. *Tijdschrift voor Onderwijsresearch, 2*(2), 49–60.

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

Skinner, B. F. (1938). *The behavior of organisms: an experimental analysis.* Appleton-Century.

Skinner, B. F. (1965). *Science and human behavior* (No. 92904). Simon and Schuster.

Solekhah, H., Kutni, I. D., and Pamungkas, A. B. (2023). Student's Engagement and Perception of Gamification in Mathematics. *Education Policy and Development*, *1*(2), 1–13.

Toda, A. M., Klock, A. C., Oliveira, W., Palomino, P. T., Rodrigues, L., Shi, L., ... and Cristea, A. I. (2019). Analysing gamification elements in educational environments using an existing gamification taxonomy. *Smart Learning Environments*, *6*(1), 1-14.

Xayrullayevna, K. B. (2024). Teaching Mathematics Interactively: Practices and Innovative Approaches. *International Journal of Pedagogics, 4(12)*, 124-126.

Yan, Y. (2023). Gamification in primary school mathematics education. *Journal of Education, Humanities and Social Sciences*, *22*, 370-376.

Yeh, C. Y., Cheng, H. N., Chen, Z. H., Liao, C. C., and Chan, T. W. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. *Research and Practice in Technology Enhanced Learning*, *14*(1), 5.