Quest Journals
Journal of Software Engineering and Simulation
Volume 12 ~ Issue 1 (January 2026) pp: 29-33
ISSN(Online) :2321-3795 ISSN (Print):2321-3809
www.questjournals.org

Research Paper

Gamification of Mathematics Using Mobile Technology

Abdulrasheed O. Ahamed, and Ibrahim Shaibu Bello
[1]*Department of Education Math/Technology, Nigerian Army School of Education, Ilorin, Kwara State, Nigeria*

Abstract
Mathematics education, particularly Discrete Mathematics, faces significant pedagogical challenges in higher education institutions due to its abstract nature and complexity. Traditional teaching methodologies often fail to engage students adequately, resulting in poor academic performance and low motivation. This comprehensive review and empirical study examine the integration of gamification strategies with mobile technology as a means to enhance mathematics learning outcomes. Drawing from recent quasi-experimental research involving 178 university students, we investigate how game-based learning activities implemented through mobile platforms affect both student engagement and academic performance in Discrete Mathematics courses. The experimental group (n=88) participated in gamified learning activities including competitive problem-solving games, crossword puzzles, and point-based reward systems accessible via mobile devices, while the control group (n=90) received traditional instruction. Pre-test and post-test assessments measuring academic performance and engagement across seven dimensions (autonomy, satisfaction with study materials, well-being, self-efficacy, classroom activity, feedback, and learning environment) revealed statistically significant improvements (p < .001) in the experimental group compared to the control group. The experimental group showed a 1.16-point improvement in academic performance versus 0.11 points in the control group, with engagement levels increasing substantially across all measured dimensions. These findings suggest that mobile technology-enabled gamification represents a promising pedagogical approach for mathematics education, particularly for complex subjects requiring sustained cognitive engagement.

Keywords: *Gamification; mobile technology; mathematics education; Discrete Mathematics; student engagement; academic performance; educational technology; STEM education*

Received 12 Jan., 2026; ***R****evised 23 Jan., 2026;* ***A****ccepted 25 Jan., 2026 © The author(s) 2026.*
P*ublished with open access at* ***www.questjournas.org***

I. Introduction

Mathematics education in higher education institutions continues to present significant challenges for both educators and learners. Among various mathematical disciplines, Discrete Mathematics (DM) occupies a particularly important position in computational and engineering curricula, encompassing specialized topics such as Graph Theory, Combinatorial Analysis, Logic, Recurrence Relations, and Set Theory (García-Hernández & González-Ramírez, 2021; Pokorny, 2013). The significance of DM extends beyond theoretical knowledge, serving as a foundational framework for modeling and simulating computational structures and problem-solving processes essential for computer science and software engineering (González-Ramírez & García-Hernández, 2020).

Despite its critical importance, DM instruction predominantly relies on traditional pedagogical approaches characterized by teacher-centered delivery, passive student reception, and limited interactive engagement (Liang et al., 2020). This conventional methodology frequently results in student disengagement, reduced motivation, and suboptimal learning outcomes. Research indicates that when students lack intrinsic interest in mathematical subjects, their attention diminishes, effort decreases, and academic performance suffers accordingly (Gil-Doménech & Berbegal-Mirabent, 2019).

The proliferation of mobile technology and its ubiquitous presence in students' daily lives presents unprecedented opportunities for educational innovation. Mobile devices offer unique affordances for learning, including accessibility, portability, interactivity, and the potential for personalized learning experiences (Crompton & Burke, 2018). When combined with gamification principles—the application of game design elements and game mechanics in non-game contexts—mobile technology can transform traditional educational environments into engaging, motivating, and effective learning ecosystems (Deterding et al., 2011).

1.1 Theoretical Framework

Gamification in education draws upon multiple theoretical foundations including Self-Determination Theory (Deci & Ryan, 2000), Flow Theory (Csikszentmihalyi, 1990), and Cognitive Load Theory (Sweller, 1988). Self-Determination Theory posits that human motivation flourishes when three fundamental psychological needs are satisfied: autonomy (sense of volition), competence (sense of effectiveness), and relatedness (sense of connection). Gamification elements such as choice, challenges, and social interaction directly address these needs (Ryan & Deci, 2017).

1.2 Research Objectives

This study addresses the following research questions: (1) How does mobile technology-enabled gamification affect academic performance in Discrete Mathematics compared to traditional instruction? (2) What is the impact of gamified mobile learning on student engagement dimensions including autonomy, satisfaction, well-being, self-efficacy, classroom activity, feedback perception, and learning environment? (3) What are the differential effects of gamification across various engagement dimensions, and which dimensions show the most substantial improvements?

II. Literature Review

2.1 Challenges in Mathematics Education

Mathematics education faces multiple interconnected challenges. Students frequently perceive mathematics as abstract, difficult, and irrelevant to their lives (Boaler, 2016). This perception contributes to mathematics anxiety—a feeling of tension and apprehension that interferes with mathematical problem-solving and number manipulation (Ashcraft & Kirk, 2001). Mathematics anxiety negatively correlates with mathematics performance and can create self-perpetuating cycles of avoidance and underachievement (Foley et al., 2017).

2.2 Gamification in Educational Contexts

Gamification—defined as the use of game design elements in non-game contexts (Deterding et al., 2011)—has gained substantial attention as a pedagogical strategy across educational levels and disciplines. Meta-analyses of gamification research indicate generally positive effects on learning outcomes, though effect sizes vary considerably depending on implementation quality, subject matter, and learner characteristics (Sailer & Homner, 2020).

2.3 Mobile Technology in Mathematics Learning

Mobile devices offer unique affordances for mathematics education including ubiquitous access, multimodal representation capabilities, and support for collaborative and personalized learning (Crompton & Burke, 2018). Mobile applications can provide immediate feedback, adaptive difficulty adjustment, and rich visualizations that support conceptual understanding (Fabian et al., 2018).

III. Methodology

3.1 Research Design

This study employed a quasi-experimental pretest-posttest control group design to investigate the effects of mobile technology-enabled gamification on academic performance and engagement in Discrete Mathematics. Quasi-experimental designs, while lacking random assignment, provide valuable insights into educational interventions in naturalistic settings where random assignment is impractical or unethical (Campbell & Stanley, 1963).

3.2 Participants

Participants comprised 178 first-year university students enrolled in Discrete Mathematics courses at Universidad de las Ciencias Informáticas, Cuba. The sample included 88 students in the experimental group and 90 students in the control group. All participants were pursuing degrees in computer science or related computational fields, representing typical populations for Discrete Mathematics instruction.

3.3 Instructional Intervention

The experimental intervention consisted of gamified learning activities delivered through mobile-accessible web platforms over eight lessons, representing approximately 25% of the complete Discrete Mathematics course. The experimental group participated in competitive problem-solving games where students answered various questions associated with Discrete Mathematics to obtain points. Depending on the complexity of the question, points were awarded from 1 to 5 (where 5 represents the maximum complexity). The highest scoring students received academic rewards as validation of assessments.

Students also engaged with crossword puzzles as gamified learning activities. Completing a crossword represented a level of mastery over the topic at hand. Additionally, students could propose exercises for the competition, and if accepted by the professor, they received bonus points. The control group received traditional instruction featuring teacher-led lectures presenting theoretical concepts, worked examples demonstrating problem-solving procedures, and assigned exercises for independent practice.

3.4 Measures and Instruments

Academic performance was measured using institutionally standardized examinations aligned with course learning objectives on a 5-point scale (2 = failure, 3 = passing, 4 = good, 5 = excellent). Student engagement was assessed using a validated multidimensional instrument measuring seven dimensions: Level of Autonomy, Satisfaction with Study Materials, Student Well-being, Student Self-efficacy, Activity in the Classroom, Feedback, and Learning Environment. Each dimension was measured using multiple items on a 5-point Likert scale.

3.5 Data Analysis

Normality of dependent variable distributions was assessed using Kolmogorov-Smirnov tests. Independent samples t-tests compared gain scores (posttest minus pretest) between experimental and control groups. Levene's test verified homogeneity of variance assumptions. Alpha level was set at .001.

IV. Results

4.1 Academic Performance Outcomes

Table 1 presents descriptive statistics and inferential test results for academic performance in Discrete Mathematics. The experimental group demonstrated substantial improvement from pretest (M = 2.81) to posttest (M = 3.97), representing a mean gain of 1.16 points. In contrast, the control group showed minimal change from pretest (M = 2.78) to posttest (M = 2.89), with a mean gain of only 0.11 points.

Variable	Control Pre	Control Post	Control Gain	Exp. Pre	Exp. Post	Exp. Gain	Diff.	p
Academic Performance	2.78	2.89	0.11	2.81	3.97	1.16	1.05	<.001

Table 1. Academic Performance Pretest, Posttest, and Gain Scores by Group

4.2 Student Engagement Outcomes

Table 2 presents comprehensive results for all seven engagement dimensions. The experimental group demonstrated substantial improvements across all engagement dimensions, while the control group showed minimal or inconsistent changes. All engagement dimension comparisons yielded p-values < .001.

Engagement Dimension	Control Pre	Control Post	Control Gain	Exp. Pre	Exp. Post	Exp. Gain	Diff.	p
Level of Autonomy	3.54	3.62	0.08	3.21	4.28	1.07	0.99	<.001
Satisfaction with Materials	1.93	1.85	-0.08	1.78	4.57	2.79	2.87	<.001
Student Well-being	2.18	2.23	0.05	2.08	3.12	1.04	0.99	<.001
Student Self-efficacy	1.78	2.01	0.23	2.12	4.19	2.07	1.84	<.001
Activity in Classroom	2.21	2.87	0.06	2.52	3.99	1.47	1.41	<.001
Feedback	2.72	2.58	-0.14	2.64	4.15	1.51	1.65	<.001
Learning Environment	3.02	3.17	0.15	2.99	4.15	1.16	1.01	<.001

Table 2. Student Engagement Dimension Scores by Group and Time

Satisfaction with Study Materials exhibited the largest improvement in the experimental group (gain = 2.79), increasing from 1.78 to 4.57. Student Self-efficacy also showed substantial improvement (gain = 2.07, from 2.12 to 4.19). Feedback perception improved considerably (gain = 1.51) while declining in the control group. Activity in the Classroom increased substantially for the experimental group (gain = 1.47 versus 0.06 for controls).

V. Discussion

This quasi-experimental study provides robust evidence that mobile technology-enabled gamification significantly enhances both academic performance and multidimensional engagement in university-level Discrete Mathematics instruction. The experimental group's substantial improvements across all measured outcomes compared to the control group's minimal changes strongly suggest that gamification represents an effective pedagogical approach for this challenging subject.

5.1 Academic Performance Improvements

The experimental group's 1.16-point improvement in academic performance versus the control group's 0.11-point gain demonstrates gamification's substantial impact on learning outcomes. Several mechanisms likely contributed to these performance gains: (1) the competitive problem-solving format encouraged repeated practice, (2) immediate feedback enabled rapid error correction, (3) adaptive difficulty through point-weighted problems allowed appropriate challenge levels, and (4) mobile accessibility enabled learning during otherwise unutilized time periods.

5.2 Engagement Dimension Improvements

The comprehensive engagement improvements across all seven dimensions provide insight into how gamification affects the student learning experience. Satisfaction with Study Materials showed the largest improvement, reflecting students' strong preference for interactive, game-based activities over traditional textbooks and lecture notes. Enhanced self-efficacy likely resulted from mastery experiences—successfully solving progressively challenging problems provided concrete evidence of competence.

5.3 Practical Implications

These results carry several implications for mathematics education practice: (1) Mathematics curricula should incorporate gamified learning activities, particularly for topics students find challenging, (2) Institutions should invest in mobile-accessible learning platforms that support gamification, (3) The point-based reward system could complement traditional assessments, and (4) Mathematics educators require training in gamification principles and implementation strategies.

5.4 Limitations and Future Directions

Several limitations warrant consideration. First, the quasi-experimental design limits causal inference compared to randomized controlled trials. Second, the eight-lesson duration represents only 25% of the complete course. Third, the study occurred in a single institution. Future research directions include: developing native mobile applications, examining different gamification elements' relative contributions, investigating individual differences, conducting longitudinal studies, and exploring collaborative gamification approaches.

VI. Conclusion

This study demonstrates that integrating gamification principles with mobile technology creates a powerful pedagogical approach for university-level Discrete Mathematics instruction. The experimental group's substantial improvements in both academic performance (1.16-point gain versus 0.11 for controls) and all seven engagement dimensions provide compelling evidence of gamification's effectiveness.

The results suggest that gamified mobile learning addresses core challenges in mathematics education by transforming abstract, challenging content into engaging, accessible activities that students perceive as enjoyable rather than onerous. The intervention enhanced students' satisfaction with materials, self-efficacy, feedback perception, classroom activity, learning environment perceptions, autonomy, and well-being—representing comprehensive improvements in the learning experience.

As mathematics education continues evolving in response to technological advances and changing student characteristics, gamified mobile learning represents a promising direction worthy of further investment and research. The challenge moving forward is not whether to gamify but how to gamify most effectively. This study contributes to that ongoing conversation by demonstrating that thoughtfully designed, theoretically grounded gamification can significantly enhance mathematics learning outcomes and student engagement.

Acknowledgement
We appreciate TETFUND for providing the resources to undertake this research.

References

[1]. Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. Journal of Experimental Psychology: General, 130(2), 224-237.
[2]. Boaler, J. (2016). Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching. Jossey-Bass.
[3]. Campbell, D. T., & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research on teaching. In N. L. Gage (Ed.), Handbook of research on teaching (pp. 171-246). Rand McNally.
[4]. Crompton, H., & Burke, D. (2018). The use of mobile learning in higher education: A systematic review. Computers & Education, 123, 53-64. https://doi.org/10.1016/j.compedu.2018.04.007
[5]. Csikszentmihalyi, M. (1990). Flow: The psychology of optimal experience. Harper & Row.

[6]. Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry, 11(4), 227-268.

[7]. Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining gamification. In Proceedings of the 15th International Academic MindTrek Conference (pp. 9-15). ACM.

[8]. Fabian, K., Topping, K. J., & Barron, I. G. (2018). Using mobile technologies for mathematics: Effects on student attitudes and achievement. Educational Technology Research and Development, 66(5), 1119-1139.

[9]. Foley, A. E., Herts, J. B., Borgonovi, F., Guerriero, S., Levine, S. C., & Beilock, S. L. (2017). The math anxiety-performance link: A global phenomenon. Current Directions in Psychological Science, 26(1), 52-58.

[10]. García-Hernández, A., & González-Ramírez, T. (2021). Technology as gamification means in mathematics learning. In Proceedings of the 7th International Conference on Higher Education Advances (pp. 581-587). Editorial Universitat Politècnica de València.

[11]. Gil-Doménech, D., & Berbegal-Mirabent, J. (2019). Stimulating students' engagement in mathematics courses in non-STEM academic programmes: A game-based learning. Innovations in Education and Teaching International, 56(1), 57-65.

[12]. González-Ramírez, T., & García-Hernández, A. (2020). Estudio de los factores de estudiantes y aulas que intervienen en el "engagement" y rendimiento académico en Matemáticas Discretas. Revista Complutense de Educación, 31(2), 195-206.

[13]. Liang, Y., Zhang, L., Long, Y., Deng, Q., & Liu, Y. (2020). Promoting effects of RtI-based mathematical play training on number sense growth among low-SES preschool children. Early Education and Development, 31(3), 335-353.

[14]. Pokorny, M. (2013). Blended learning as an efficient method for discrete mathematics teaching. In Proceedings of the 2013 International Conference on Education and Educational Research (pp. 249-252).

[15]. Ryan, R. M., & Deci, E. L. (2017). Self-determination theory: Basic psychological needs in motivation, development, and wellness. Guilford Press.

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

[17]. Sun-Lin, H. Z., & Chiou, G. F. (2019). Effects of gamified comparison on sixth graders' algebra word problem solving and learning attitude. Journal of Educational Technology & Society, 22(1), 120-130.

[18]. Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive Science, 12(2), 257-285.