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Using Gamification in Teaching Mathematics

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Abstract

This study examined the effectiveness of Gamified Physical Games (GPGs) as an intervention tool in teaching Mathematics among Grade 6 students of Sapang Ama Integrated School during the Academic Year 2024–2025. Guided by the gamification framework of Landers and Landers (2014), the study utilized a one-group quasi-experimental pretest-posttest research design to determine the impact of GPGs on students' mathematical achievement and attitudes toward Mathematics. The respondents consisted of 31 Grade 6 students who participated in a five-week intervention integrating 25 gamified physical games into Mathematics instruction. The study employed a validated 50-item Mathematics achievement test and the TIMSS 2019 Mathematics Attitude Questionnaire (Martin et al., 2020) as research instruments. Data were analyzed using arithmetic mean, weighted mean, paired-samples t-test, and Pearson Product-Moment Correlation. Findings revealed that students' Mathematics performance significantly improved after the intervention, with mean scores increasing from Low Mastery during the pre-test to Near Mastery during the post-test. Results further indicated a significant difference between pre-test and post-test scores, demonstrating the effectiveness of GPGs in enhancing mathematical achievement. Students maintained a positive attitude toward Mathematics before and after the intervention; however, no significant change in attitude was observed. Moreover, the relationship between students' attitudes and Mathematics achievement showed a weak positive but non-significant correlation. The study concluded that Gamified Physical Games are effective instructional tools that make Mathematics learning more engaging, interactive, and meaningful for learners. The study recommended integrating GPGs into Mathematics instruction and providing teachers with professional development opportunities related to gamified learning strategies. The study supports Sustainable Development Goal 4 (Quality Education) by promoting inclusive, engaging, and effective learning strategies that improve students' mathematical achievement and classroom participation. It also contributes to sustainable educational practices by encouraging innovative and learner-centered instructional approaches that can strengthen long-term academic engagement and teaching effectiveness in basic education.

Keywords: Attitude Towards Mathematics, Gamified Physical Games, Grade 6 Students, Mathematics Achievement, Mathematics Instruction, One-Group Pretest-Posttest Design, Quasi-Experimental Design, Student Engagement, Teaching Mathematics

1. Introduction

Mathematics is recognized as a universal discipline that develops learners' critical thinking and problem-solving abilities necessary for life and work (K to 12 Mathematics Curriculum Guide, 2016). The K–12 Mathematics curriculum emphasizes skills such as reasoning, estimating, visualizing, modeling, communication, and decision-making (Scriven & Paul, 1987; Polya, 1945, 1962). However, students commonly struggle with Mathematics because of its abstract nature, cognitive demands, and accumulated foundational gaps (Geary, 2004; Geary et al., 2000; Hanich et al., 2001). Several factors contribute to students' difficulties in Mathematics, including low prior knowledge, poor memory retention, limited self-efficacy, anxiety, and negative attitudes toward the subject (Gafoor & Kurukkan, 2015; Murayama et al., 2013; Harari et al., 2013; Barroso et al., 2021). Students also encounter challenges in applying mathematical operations, understanding concepts, analyzing problems, and solving word problems (Velez et al., 2023; Cortes et al., 2016). These difficulties are compounded in the Philippine context by linguistic barriers and inadequate instructional support (Hamak et al., 2014). Gamification offers an alternative instructional approach by incorporating game elements such as rewards, points, challenges, and competition into learning environments (Kapp, 2012). Research indicates that gamification enhances learner engagement, motivation, conceptual understanding, and academic performance in Mathematics (Smith, 2018; Jagust et al., 2018; Kiili et al., 2015). In schools with limited access to digital technology, integrating physical games into instruction presents a practical and cost-effective strategy for increasing student participation and enjoyment (Clark & Wilson, 2023; Su & Cheng, 2023).

The literature highlights several recurring themes regarding Mathematics learning and gamification. One major theme involves students' persistent difficulties in mastering foundational mathematical concepts because of cognitive, emotional, and instructional barriers (Chinn, 2020; Geary, 2011). Learners often experience anxiety, low confidence, and negative perceptions toward Mathematics, which reduce engagement and achievement (Gafoor & Kurukkan, 2015; Gierl & Bisanz, 1995; Ariffin et al., 2022). Another theme emphasizes the effectiveness of gamification in promoting motivation, participation, and academic achievement. Studies have shown that gamified learning environments improve students' interest, conceptual understanding, and problem-solving skills (Molina-Villarroel et al., 2021; Atin et al., 2022; Funa & Ricafort, 2019; Huang & Hew, 2018; Yildirim, 2017; Sakai & Shiota, 2016). Gamification also supports self-efficacy, intrinsic motivation, and collaborative learning through interactive and rewarding experiences (Bandura, 1977; Ryan & Deci, 2017; Schunk & DiBenedetto, 2021). Research further suggests that physical activity contributes positively to cognitive functioning and academic performance. Physically active lessons improve attention, working memory, executive functioning, and problem-solving abilities relevant to Mathematics learning (Magistro et al., 2022; Verburgh et al., 2016; Kubesch et al., 2009). Gamified physical activities create stimulating learning environments that encourage teamwork, participation, and sustained engagement (Julianti et al., 2019; Slade, 2016). However, literature also reveals mixed findings regarding gamification. Some studies reported reduced intrinsic motivation, declining engagement, or no significant improvement in performance when gamification was poorly implemented (Hanus & Fox, 2015; Toda et al., 2017; De-Marcos et al., 2014). These findings indicate the importance of carefully designing gamified interventions to maximize educational benefits.

Globally, Mathematics education remains a significant concern due to declining student motivation, anxiety, and low achievement levels. Studies across different countries have identified gamification as an effective strategy for increasing learner engagement and improving mathematical outcomes (Rincon-Flores et al., 2023; Zabala-Vargas et al., 2021; Molano, 2022). International educational systems increasingly integrate active and student-centered approaches to address learners' cognitive and emotional challenges in Mathematics. Nationally, the Philippine K–12 curriculum promotes higher-order thinking skills and real-life application of mathematical concepts (K to 12 Mathematics Curriculum Guide, 2016). However, many Filipino learners continue to struggle with mathematical comprehension, procedural skills, and language-related difficulties (Hamak et al., 2014). Limited access to technology and inadequate infrastructure in remote schools further constrain innovative teaching practices (Tomaro & Mutiarin, 2018; Kamat & Nasnodkar, 2019). Locally, Grade 6 students often encounter difficulties with fundamental operations involving fractions, decimals, and word problems. These challenges become more critical as learners transition to higher grade levels requiring advanced mathematical competencies (Geary, 2011). In response, educators seek alternative strategies such as Gamified Physical Games (GPGs) to improve engagement, understanding, and achievement in Mathematics within resource-limited contexts.

This study was anchored on Gamified Learning Theory, which explains how gamification influences learning behaviors, attitudes, and outcomes through motivational and behavioral mechanisms (Landers, 2014). Gamification can function as a moderating factor that enhances existing instruction or as a mediating factor that directly influences learning outcomes by promoting targeted behaviors and attitudes. The study also draws from Constructivist Theory, particularly the works of Piaget (1970) and Vygotsky (1978), which emphasize active engagement, experiential learning, and social interaction in knowledge construction. Gamified activities encourage learners to participate actively in problem-solving, decision-making, and collaborative learning experiences. Bandura's (1977) Self-Efficacy Theory further supports the study by emphasizing that learners' beliefs in their abilities influence motivation, persistence, and achievement. Gamified learning environments provide mastery experiences, peer support, and positive reinforcement that strengthen mathematical self-efficacy (Usher & Pajares, 2009). Additionally, Self-Determination Theory proposed by Ryan and Deci (2020) explains that motivation increases when learners experience autonomy, competence, and relatedness. Gamified learning activities satisfy these psychological needs by offering meaningful challenges, rewards, collaboration, and opportunities for achievement (Deci et al., 1991; Sillaots, 2015; De-Marcos et al., 2016).

Although numerous studies have investigated digital gamification in Mathematics education, limited research has focused on Gamified Physical Games (GPGs), particularly in non-digital and resource-constrained educational settings (Antonio & Tamban, 2022). Existing studies predominantly emphasize mobile applications, video games, and technology-based platforms, leaving a gap in understanding the educational potential of physical gamified interventions. Moreover, prior research produced inconsistent findings regarding the effectiveness of gamification on motivation, achievement, and attitudes (Hanus & Fox, 2015; Toda et al., 2017; De-Marcos et al., 2014). These mixed results indicate the need for further investigation into how gamification can be effectively designed and implemented in diverse learning environments. The present study addressed these gaps by examining the effectiveness of GPGs in improving mathematical achievement and sustaining positive attitudes among Grade 6 learners in a public integrated school with limited technological resources. Specifically, the study investigated students' mathematical performance before and after the intervention and explored the relationship between attitudes toward Mathematics and academic achievement.

This study aligns with several Sustainable Development Goals (SDGs). Primarily, it supports SDG 4 – Quality Education by promoting inclusive, equitable, and effective learning strategies that improve student engagement and achievement in Mathematics. The integration of GPGs contributes to innovative teaching practices that enhance learning outcomes and foster lifelong learning opportunities. The study also aligns with SDG 9 – Industry, Innovation and Infrastructure through the exploration of innovative instructional methods that can be implemented even in resource-limited educational settings. By utilizing non-digital gamification, the research demonstrates how creative and sustainable educational innovations can improve teaching and learning processes. Additionally, the study relates to SDG 3 – Good Health and Well-Being because gamified physical activities encourage movement, active participation, and social interaction, which may positively influence learners' physical and psychological well-being (Magistro et al., 2022; Julianti et al., 2019). The collaborative and participatory nature of GPGs also reflects SDG 17 – Partnerships for the Goals, as effective gamified learning environments encourage cooperation, peer interaction, and shared learning experiences among students and educators.

This study contributes to multiple dimensions of sustainability, particularly educational, technological, socio-economic, and community sustainability. In terms of educational sustainability, the research promotes innovative and engaging teaching practices that enhance student learning, motivation, and long-term academic development. From a technological and innovation sustainability perspective, the study demonstrates that effective gamification does not necessarily depend on expensive digital technologies. Instead, low-cost and non-digital interventions such as GPGs can provide meaningful learning experiences in underserved schools and remote communities. The study also supports socio-economic sustainability by improving mathematical competencies essential for future educational attainment, employability, and workforce readiness. Mathematical literacy is closely associated with economic productivity, critical thinking, and problem-solving capacities necessary in modern society. Furthermore, the collaborative and interactive nature of GPGs contributes to community and social sustainability by fostering teamwork, communication, peer support, and positive classroom relationships. These skills are essential for creating inclusive and supportive educational environments that promote holistic learner development.

2. Material and methods

2.1 Research Design

The study utilized a quasi-experimental one-group pretest-posttest design. A pre-test was administered to establish baseline measures of students' mathematical achievement and attitudes toward Mathematics before the intervention. After the implementation of the Gamified Physical Games (GPGs), a post-test and post-survey were conducted to determine changes in achievement and attitudes. Although the design did not include a control group, it enabled the researcher to evaluate the effectiveness of GPGs in teaching Mathematics and their influence on learners' mathematical achievement and attitudes.

2.2 Locale of the Study

The study was conducted at Sapang Ama Integrated School, a public integrated school located in Sapang Dalaga, Misamis Occidental. The school serves learners from Kindergarten to Senior High School with a population of 317 students. It is staffed by seven elementary teachers and ten high school teachers under the supervision of a principal. The school also serves learners from nearby coastal barangays, including Macabibo, Libertad, and Caluya, which function as feeder communities contributing to the school population. The close relationship between the school and neighboring communities supports collaboration and resource sharing that enrich students' educational experiences.

2.3 Respondents of the Study

The respondents of the study were all Grade 6 students enrolled at Sapang Ama Integrated School during the Academic Year 2024–2025. A total of 31 learners participated in the study, consisting of 17 boys and 14 girls aged 10 to 13 years old. The selected respondents provided a focused group for examining the effectiveness of GPGs within the school's specific educational and cultural context.

2.4 Sample and Sampling Procedure

The study employed total population sampling by involving all Grade 6 students of Sapang Ama Integrated School. The researcher selected the participants because they were directly enrolled in the target grade level where the intervention was implemented. The inclusion of all learners ensured a comprehensive analysis of students' mathematical achievement and attitudes before and after exposure to the GPG intervention.

2.5 Research Instrument

The study utilized several research instruments to gather data. A researcher-developed 50-item multiple-choice Mathematics achievement test was administered as both pre-test and post-test to assess students' mastery of the mathematical concepts and skills covered during the intervention. The instrument focused on competencies from the Grade 6 Mathematics curriculum and was validated by experts to ensure content accuracy and alignment with educational standards. Students' attitudes toward Mathematics were measured using the TIMSS 2019 Mathematics Attitude Questionnaire (Martin et al., 2020), which included 27 items covering three dimensions: Like Mathematics, Value Mathematics, and Confidence in Mathematics. The instrument was used to determine students' attitudes before and after the intervention. The intervention materials also included validated lesson plans integrating 25 different Gamified Physical Games designed to make Mathematics instruction interactive and engaging. The games incorporated gamification elements such as points, badges, rewards, cooperative activities, and leaderboards to encourage participation and motivation during Mathematics lessons.

2.6 Data Gathering Procedure

The researcher first secured and validated the research instruments, including the lesson plans, achievement test, and survey questionnaire. Necessary revisions were incorporated before the final administration of the instruments. Permission to conduct the study was obtained from the Schools Division Superintendent, Public School District Supervisor, and the principal of Sapang Ama Integrated School. To ensure ethical compliance, informed consent was obtained from school authorities, parents or guardians, and participating students. Parental consent forms explained the nature, purpose, procedures, risks, benefits, confidentiality measures, and participants' rights, while student assent forms were presented using age-appropriate language. Participation was voluntary, and students were informed of their right to withdraw at any point without penalty. The intervention integrated gamification elements such as points, badges, and leaderboards into Mathematics learning activities. Group performance and participation were rewarded through a point-based recognition system that translated accumulated points into achievement badges. Special badges were also awarded for participation, perfect scores, and attendance to promote healthy competition and sustained engagement. The intervention lasted for five weeks and followed the Department of Education's prescribed Mathematics time allotment. Each session lasted 50 minutes and was conducted during the regular Mathematics class schedule. The first week focused on the administration of the pre-test and orientation regarding the intervention, while succeeding sessions involved the implementation of GPG activities based on the prepared lesson plans. The sixth week involved the administration of the post-test and post-survey to measure students' learning gains and changes in attitudes toward Mathematics.

2.7 Data Analysis Techniques

The collected data were organized and analyzed using statistical software. Descriptive statistics such as mean, standard deviation, frequency, and percentage were employed to describe the characteristics of the data and determine students' levels of achievement and attitudes toward Mathematics. Arithmetic mean was used to analyze pre-test and post-test scores and determine the effectiveness of GPGs in improving mathematical achievement. Weighted mean was utilized to determine students' attitudes toward Mathematics before and after the intervention. A paired-samples t-test was used to determine significant differences between pre-test and post-test scores and between pre-survey and post-survey attitudes. Pearson Product-Moment Correlation was applied to determine the relationship between students' mathematical achievement and their attitudes toward Mathematics after participating in the GPG intervention. The interpretation of correlation strength followed the scale adapted from Calderon and Gonzales (1986).

2.8 Ethical Considerations

The study adhered to ethical principles throughout the research process to ensure participants' safety, privacy, and well-being (Medico et al., 2023). Confidentiality and anonymity were strictly observed, and all collected information was treated with utmost privacy. Access to sensitive data was limited only to the researcher, and participant identities were protected throughout the study.

3. Results and Discussion

3.1 Students' Mathematics Performance Using Gamified Physical Games

3.1.1 Performance in Mathematics Before and After the Intervention

The findings revealed that students initially demonstrated low mastery in Mathematics during the pre-test, with most learners scoring within the lowest mastery range and obtaining a mean score of 15. After the implementation of the Gamified Physical Games (GPGs), students' post-test performance improved substantially, with the mean score increasing to 28, interpreted as near mastery. Several students also reached mastery and near full mastery levels after the intervention. The improvement in students' Mathematics performance suggests that GPGs contributed positively to learners' understanding of mathematical concepts and engagement during instruction. The integration of game-based activities encouraged active participation, collaboration, and enjoyment in learning, which likely enhanced retention and comprehension of lessons. These findings support the effectiveness of gamification strategies in improving academic achievement and creating a more stimulating learning environment for Mathematics instruction.

3.1.2 Difference Between Pre-Test and Post-Test Scores

The results showed a significant difference between students' pre-test and post-test scores following the implementation of GPGs. Students performed better after the intervention, indicating that the use of gamified physical activities enhanced their mathematical achievement. The increase in scores demonstrated that the intervention effectively improved students' mastery of the mathematical competencies covered during the study. The significant improvement in achievement may be attributed to the interactive and engaging nature of the GPG intervention. Through physical games integrated into

Mathematics instruction, students were encouraged to participate actively and apply mathematical concepts in collaborative learning situations. Gamification elements such as rewards, points, and competition may have increased motivation and sustained learners' attention throughout the intervention period. These findings affirm that gamified learning approaches can support meaningful learning experiences and improved academic outcomes in Mathematics.

3.2 Students' Attitudes Toward Mathematics

3.2.1 Attitudes Toward Mathematics Before the Intervention

Before the intervention, students already exhibited positive attitudes toward Mathematics in terms of liking the subject, valuing its importance, and demonstrating confidence in learning mathematical concepts. The results indicated that students generally maintained a favorable disposition toward Mathematics even prior to the implementation of GPGs. The positive attitudes observed before the intervention suggest that students recognized the value of Mathematics and possessed an initial level of interest in the subject. Positive attitudes toward Mathematics are important because they contribute to learners' willingness to participate in classroom activities and engage in problem-solving tasks. This favorable disposition may have also supported students' responsiveness to the gamified intervention.

3.2.2 Attitudes Toward Mathematics After the Intervention

After the implementation of GPGs, students continued to demonstrate strongly positive attitudes toward Mathematics. Learners maintained positive perceptions regarding enjoyment, confidence, and appreciation of Mathematics following participation in the gamified activities. The intervention sustained students' enthusiasm and interest in learning the subject. The sustained positive attitudes after the intervention indicate that GPGs helped maintain students' engagement and appreciation for Mathematics. The incorporation of collaborative and enjoyable learning experiences may have encouraged learners to participate more confidently and enthusiastically during lessons. Although the intervention may not have drastically altered students' attitudes, it reinforced and preserved their positive disposition toward Mathematics.

3.2.3 Difference Between Pre- and Post-Intervention Attitudes

The findings revealed that there was no significant difference between students' attitudes toward Mathematics before and after the intervention. Despite the absence of a statistically significant change, students consistently demonstrated strongly positive attitudes toward the subject throughout the study period. The absence of a significant shift in attitude may be explained by the already high level of positive attitudes exhibited by students prior to the intervention. Since learners already viewed Mathematics positively, the intervention may have served more as a sustaining factor rather than a transformative one. The findings suggest that while GPGs effectively maintained students' interest and engagement, additional or longer-term interventions may be necessary to produce significant changes in attitudes toward Mathematics.

3.3 Relationship Between Mathematics Attitude and Achievement

3.3.1 Correlation Between Attitude and Mathematical Achievement

The study found a weak positive but non-significant relationship between students' attitudes toward Mathematics and their post-test achievement scores after the intervention. Although students generally exhibited positive attitudes, these attitudes did not strongly predict their academic performance in Mathematics. The findings suggest that while positive attitudes contribute to learners' educational experiences, they are not the sole determinant of academic success. Bandura's (1986) Social Cognitive Theory explained that beliefs and attitudes influence achievement but do not function independently. Students may possess positive attitudes toward Mathematics yet still encounter difficulties due to limited self-confidence or insufficient opportunities to practice mathematical skills. Similarly, Wang and Degol (2017) emphasized that the relationship between attitudes and achievement may vary depending on instructional quality, intrinsic motivation, and learning experiences. Bernardo (2008) also found that positive attitudes are more likely to improve achievement when supported by effective instruction and adequate learning support systems. Furthermore, Tan and Librea (2013) suggested that academic performance in the Philippines is influenced by multiple contextual factors such as family expectations, peer influence, and available educational resources. The findings also align with Moussa and Saali (2022), who explained that positive attitudes do not always translate into improved assessment performance, and Papadakis et al. (2022), who noted that external pressures and contextual factors may interfere with the relationship between attitude and achievement. Overall, the results demonstrate that although positive attitudes are beneficial, academic achievement in Mathematics is shaped by a combination of cognitive, motivational, instructional, and environmental factors.

4. Conclusion & Recommendations

Gamified Physical Games (GPGs) proved to be an effective intervention in improving the mathematical performance of Grade 6 students. The study revealed significant improvement in students' post-test scores, moving from Low Mastery to Near Mastery after the implementation of the intervention. Although students' attitudes toward Mathematics remained consistently positive before and after the intervention, no significant change in attitude was observed. Furthermore, the relationship between students' attitudes and Mathematics achievement showed a weak positive but non-significant correlation, indicating that academic achievement may also be influenced by other factors such as instructional quality, engagement strategies, and cognitive development. Overall, the findings demonstrated that GPGs are valuable in making Mathematics learning more interactive, engaging, and effective.

Schools may integrate Gamified Physical Games (GPGs) as part of the mathematics curriculum to support students' progressive skill development and engagement in learning. Teachers may also be provided with professional development opportunities focused on gamified instructional strategies, classroom management, and adaptation of GPGs for learners with varying skill levels. In addition, supplementary GPG activities may be designed to address students' difficulties in operations involving fractions, mixed numbers, decimals, and multi-step problems through scaffolded and time-appropriate tasks. Integrating explicit problem-solving strategies within GPG activities may further strengthen students' understanding and confidence in solving mathematical problems effectively.

Compliance with ethical standards

The authors declare no conflict of interest. This study complied with recognized ethical standards for human-participant research by ensuring voluntary participation with informed consent, the right to withdraw without penalty, and strict confidentiality through anonymous, secure, and aggregated data handling. Given the focus on psychological well-being, procedures were non-invasive, and safeguards were observed to minimize discomfort, with guidance to appropriate support services when needed, and required institutional permissions were secured for instrument use and access to academic records.

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