The Effects of Gamification in Middle School Math and Science Classrooms

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Abstract

This study investigates the impact of gamification strategies on student engagement, problem-solving skills, and academic achievement in 6th-grade math and science classrooms. Using mixed-methods, this study will compare two groups of students: one receiving instruction through gamified strategies and one receiving traditional instruction. Participants will include approximately 50–60 students from a diverse public middle school in Baltimore County, Maryland. The experimental group will experience a 10-week gamified curriculum using platforms like Kahoot and Desmos, along with badges, points, and leaderboards. The control group will follow the same curriculum without gamification. Quantitative data will be collected through pre- and post-intervention assessments, engagement surveys, and problem-solving tasks. Qualitative data will be gathered through classroom observations, teacher journals, and student interviews. Data analysis will include descriptive and inferential statistics, thematic coding, and triangulation of data sources to explain both outcomes and underlying student experiences. It is anticipated that students in the gamified group will demonstrate higher levels of engagement, stronger problem-solving abilities, and improved academic performance compared to their peers. Findings may inform future instructional practices and provide a model for integrating gamification into middle school STEM education. Results will also contribute to the limited but growing research on the effectiveness of gamified learning environments in hybrid and in-person settings.

Introduction

Teachers are constantly faced with the challenge of engaging students who grow up in a world immersed in technology. Students typically disengage during a lesson, not always because

of the content itself but because the mode of delivery can cause a disconnect at times for students who are constantly surrounded by technology. Despite their best efforts, many teachers find this struggle reflects a growing gap between what students need developmentally and what many classrooms currently provide.

Research shows that academic engagement declines as students advance through middle and high school, particularly in science and math (Barna & Fodor, 2018). Traditional instruction often leaves little room for students to feel ownership over their learning or see relevance in the work they're asked to do. Students can feel disconnected from their natural curiosity, creativity, and social instincts if they do not have a connection to learning the material.

Gamification has emerged as a potential way to fix this problem by tapping into the same forces that drive students to master video games or collaborate in online challenges: autonomy, recognition, and problem-solving. When thoughtfully implemented, they can offer a framework that aligns with adolescent developmental needs and promotes deeper engagement in core subjects. While these strategies are growing in popularity, especially in tech-rich environments, little is known about how they impact student engagement, problem-solving, and academic achievement in middle school classrooms. Without a clearer understanding of how gamified learning environments function in practice, educators risk relying on traditional methods that may no longer meet the needs of today's learners.

The purpose of this study is to examine how the integration of gamification strategies in middle school math and science impacts student engagement, problem-solving skills, and academic achievement. By identifying the mechanisms that foster cognitive engagement, the study aims to provide practical, evidence-based guidance for educators seeking to implement game-based instructional methods. To explore the impact of gamification in middle school math

and science classrooms, this research will focus on the question: *In what ways do implementing gamification in middle school math and science classrooms affect students' engagement, problem-solving abilities, and academic achievement compared to traditional instruction?*

Literature Review

Current research highlights the potential of gamified learning to enhance student engagement, motivation, problem-solving, and academic performance, particularly in STEM education (Barna & Fodor, 2018; Dicheva et al., 2015; Stohlmann, 2023). Game-based elements such as points, rewards, and leaderboards have been shown to foster active participation and persistence when meaningfully aligned with instructional goals (Barata et al., 2013). Anderson et al. (2018) observed increased engagement and problem-solving skills in middle school science classrooms using game-based instruction, while Bal (2019) and Ke, Dai, and West (2024) also reported positive academic outcomes linked to gamified environments. These findings suggest that gamification can support technology-immersed learners by creating more interactive and motivating educational experiences.

Despite these promising results, several limitations in the current body of research raise important considerations. Many studies focus on short-term outcomes or narrow age ranges, often with elementary students which limits their application to secondary education (del Olmo-Muñoz et al., 2023). Additionally, few examine the long-term effects of gamification on deeper conceptual understanding or its impact on intrinsic motivation (Dicheva et al., 2015). Using singular platforms or isolated subject areas further restricts insight into its cross-disciplinary potential. Moreover, there is a critical lack of research comparing the effects of gamification in online versus in-person learning environments, despite the growing shift toward hybrid models

(Barna & Fodor, 2018). To address these gaps, further studies using mixed methods should explore how gamified learning environments influence student engagement, equity, and achievement across varied contexts and over time.

Gamification has potential solutions to the widespread challenge of student disengagement, particularly in STEM fields and hybrid learning environments. Given the promising yet varied findings across existing studies, further investigation into their impact is essential. A deeper understanding of how these strategies influence engagement, motivation, and academic achievement can help educators make data-informed decisions about incorporating gamified methods to enhance learning outcomes in diverse classroom settings.

This proposal explores the effects of gamification on middle school students' engagement, problem-solving skills, and academic achievement in math and science classrooms, both in-person and online. This study hypothesizes that implementing gamified and game-based instructional strategies will significantly increase student engagement, enhance students' problem-solving abilities, and improve academic achievement compared to traditional instructional methods.

Methods

Participants and Sampling

This study will involve a sample of 6th grade students from a public middle school in Baltimore County, Maryland, where the researchers currently teach. The school serves a diverse student population across various racial, ethnic, and socioeconomic backgrounds. Participants will be drawn from two comparable 6th grade math and science classes that were selected through convenience sampling based on the researchers' teaching assignments. One class will serve as the experimental group and one as the control group.

Students typically range in age from 11 to 12 years. The demographic distribution of the school includes approximately 50% African American, 35% White, 10% Hispanic, 3% Asian, and 2% multiracial students, with a near-even gender balance, which is expected to be reflected in the sample. All students enrolled in the selected classes will be eligible to participate unless they are receiving individualized instruction in separate settings due to specific IEP requirements that preclude participation in whole-class activities. A feasible sample size is approximately 50–60 students total (25–30 in each group), which allows for meaningful analysis while remaining manageable within the constraints of classroom-based research.

Research Design

The research will use a combination of qualitative and quantitative methods to compare outcomes between two groups of students, one of which will receive instruction through gamification. A comparison group will receive the traditional instruction. The qualitative component will include classroom observations, student interviews or focus groups, and teacher journaling. Quantitative data will be collected first to measure changes in student outcomes before and after the intervention. Qualitative data will be collected throughout the intervention period to capture student behaviors, perceptions, and insights. Quantitative findings will be examined alongside qualitative themes to provide a more comprehensive understanding of how and why gamification may influence engagement, problem-solving, and achievement. This design supports triangulation, strengthens validity, and helps explain not only whether the intervention works, but how it is experienced by students in practice.

Measures

The independent variable in this study is the implementation of gamification strategies within instructional practices. These strategies may include the use of platforms and tools such as Kahoot and Desmos, digital badges, point systems, leaderboard challenges, and educational escape rooms. The dependent variables are student engagement, problem-solving skills, and academic achievement. Student engagement will be measured through pre- and post-intervention surveys, attendance records, and participation tracking. Problem-solving skills will be assessed using structured tasks or performance-based assessments, while academic achievement will be evaluated by comparing students' test scores, quiz results, and assignment grades before and after the implementation of gamification.

Intervention and Procedures

The intervention will involve incorporating gamification elements into regular 6th-grade math and science instruction over 10 weeks. The gamification strategies will include points that will be awarded for task completion, collaboration, and persistence, badges that can be earned for academic achievements such as mastering a concept or demonstrating problem-solving strategies, and leaderboards to track progress and celebrate milestones that focus on individual growth rather than competition.

The intervention will be implemented by the classroom teachers, both of whom have prior experience integrating digital learning tools and game-based strategies in instruction. No external professional development will be required, though time will be allocated prior to the intervention to collaboratively develop the gamified lessons and materials. The comparison group will continue with standard curriculum-based instruction without the added gamification elements.

Before the study begins, parental consent and student assent will be obtained. In Week 1, students in both the experimental and comparison groups will complete pre-intervention assessments and engagement surveys. From Weeks 2 to 10, the gamification strategies will be applied consistently across both math and science lessons in the experimental group. Weekly lessons will include gamified components aligned to instructional goals, and researchers will conduct classroom observations and maintain teacher journals to document implementation and student responses. The comparison group will follow the same curriculum content but without gamification.

In Week 11, students will complete post-assessments and surveys. Additionally, a subset of students from the experimental group will participate in brief interviews or focus groups to gather qualitative data about their experiences. In Week 12, the researchers will analyze both the quantitative and qualitative data, looking for trends, differences, and insights that answer the research question. This structured and manageable plan ensures that the intervention is realistic, well-supported by existing instructional tools, and logistically feasible within a standard school schedule.

Data Collection

This study will use standardized and research-based instruments to collect quantitative and qualitative data. Student engagement and motivation will be measured using the Student Engagement Instrument (SEI), a validated self-report measure for middle and high school students. The SEI has demonstrated strong reliability (Cronbach's $\alpha = .88$) and validity across diverse student populations (Appleton, Christenson, Kim, & Reschly, 2006).

Academic achievement will be assessed using district-administered benchmark assessments in math and science that align with state standards. While formal reliability and

validity data for these district assessments may not be publicly available, their use in system-wide instructional decision-making and accountability processes supports their face and content validity for measuring academic performance.

For qualitative data, weekly classroom observations will be conducted using an adapted version of the Behavioral Observation of Students in Schools (BOSS) protocol (Shapiro, 2004). This structured observation tool captures both academic engagement and off-task behavior using momentary time sampling. BOSS has been widely recognized as an efficient and empirically supported method for assessing student engagement in classroom settings, particularly within problem-solving consultation models (Volpe, Briesch, Chafouleas, & Riley-Tillman, 2010). Adaptations in this study will focus on identifying engagement behaviors specific to gamified instruction. The original BOSS protocol has demonstrated strong inter-rater reliability (above 0.80), supporting its use in classroom research.

Semi-structured student interviews will be conducted with a representative subset of students in the experimental group to explore their perceptions of the gamified learning environment. The interview protocol will include questions about engagement, perceived difficulty, motivation, and enjoyment such as, “What parts of the game-based lessons made learning more interesting or challenging?”. Interviews will be conducted by the teacher-researchers who will use a script to ensure consistency while allowing for follow-up questions. Transcripts will be coded thematically during the interpretation phase to triangulate with quantitative data.

Data Analysis

The analysis of quantitative data will involve both descriptive and inferential statistical methods, drawing on the framework outlined by Mills and Jordan (2023). Descriptive statistics will summarize student engagement and motivation scores collected through the Student Engagement Instrument (SEI). To evaluate the effectiveness of gamified instruction, inferential analyses will be conducted. A paired-sample t-test will compare pre- and post-intervention scores, and ANOVA may be employed if comparisons across multiple groups or instructional approaches are needed. Additionally, correlational analysis may be employed to explore relationships between engagement and motivation.

Qualitative data from classroom observations using the adapted Behavioral Observation of Students in Schools (BOSS) protocol will be analyzed descriptively by tallying and comparing frequencies of observed behaviors over time. The results will be used to identify behavioral patterns associated with gamified instruction. When applicable, thematic coding of narrative field notes will be used to supplement quantitative findings and provide context to classroom behaviors.

Thematic analysis of field notes from observations will be utilized to supplement quantitative findings. This provides context to classroom behavior and shows the variation of student engagement and motivation. This qualitative analysis will enrich the study by illustrating specific occurrences of problem-solving strategies utilized by students during the gamification strategies.

Mixed-methods measurements will be used to integrate both quantitative and qualitative findings. This will allow for a more comprehensive understanding of the impacts of gamification

and game-based elements. By combining quantitative and qualitative analyses as mixed methods, the research aims to provide a comprehensive understanding of how gamification can benefit students in the middle school math and science classroom.

Timeline

The study will be conducted over 12 weeks. Prior to beginning the intervention, parental consent and student assent will be obtained.

Week 1	Pre-intervention assessments and engagement surveys will be administered to both groups.
Weeks 2-10	The experimental group will receive instruction using gamification strategies, including digital badges, point systems, leaderboards, Kahoot, Desmos, and escape room tasks. The control group will receive traditional instruction using the same content. Gamified components will be aligned to weekly instructional goals and implemented consistently by teachers with prior experience in game-based learning. Independent variable monitoring: Implementation fidelity will be ensured through teacher journaling and weekly classroom observations, which will track consistency and student responses.
Week 11	Both groups will complete post-assessments and engagement surveys. A subset of students from the experimental group will participate in focus groups or interviews.

Week 12	Data analysis will be conducted.

Anticipated Outcomes

The results of this study should yield outcomes that suggest game-based learning elements and gamification strategies show improvement in student engagement, problem-solving, and academic achievement. Data collected from the Student Engagement Instrument (SEI), benchmark assessments, and classroom observations will support the hypothesis. This outcome directly assesses the research regarding the effectiveness of gamification and game-based elements integrated into instruction. Improved scores on self-assessments and benchmark assessments could demonstrate the effectiveness.

If shown to be successful and effective, the research may encourage educators, administrators, curriculum writers, and districts to adopt similar gamification and game-based learning strategies in the modern classroom. Although these are the anticipated outcomes, variations in student responses and external factors could influence the validity of the results. Future research and continued implementation of game-based elements in the classroom could examine the long-term impacts on student engagement and achievement.

Conclusion

Future research should explore the long-term effects of gamification across different grade levels and subject areas, examine its impact on diverse student populations, and investigate how specific game elements influence learning outcomes. Continued research in this area can

improve the best practices in instruction and ensure equitable access to engaging and effective learning experiences. This study will contribute to the growing body of evidence supporting the use of gamification in education by providing both quantitative and qualitative insights into its impact on middle school math and science students.

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