The Impact of Gamified Active Learning Strategies on Student Engagement and Academic Performance in Secondary-Level Introductory Physics Courses

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Abstract

This study investigated the impact of gamified active learning strategies on student engagement and academic performance in secondary-level introductory physics courses at Government High School Number 1, Dera Ghazi Khan. Using a quasi-experimental design, two groups of 9th-grade students (experimental and control) were compared. The experimental group was exposed to gamified learning, incorporating game elements like rewards, competition, and interactive activities, while the control group received traditional instruction. Data were collected through pre-tests and post-tests for academic performance, as well as self-reported questionnaires and classroom observations for student engagement. The results revealed that the experimental group showed significant improvements in both academic performance and student engagement, indicating the effectiveness of gamification in enhancing learning outcomes. The study concluded that gamified active learning strategies can foster greater student participation and motivation, leading to improved academic results. The findings suggest that gamification should be integrated into other subjects and grade levels to further explore its potential in secondary education.

Keywords: Gamified Active Learning, Student Engagement, Academic Performance, Secondary Education, Physics, Quasi-experimental Design, Gamification, Educational Strategies

Introduction

In various academic domains, underscoring the critical need to investigate its influence within the specific context of secondary-level introductory physics education. This paper explores how gamified active learning strategies can significantly enhance student engagement and academic performance in such courses, addressing the limitations of traditional pedagogical approaches (Abenes et al., 2023) (Costa & Reis, 2025). The integration of gamification, characterized by elements like points, badges, and leaderboards, with active

learning methodologies, such as those within an Investigative Science Learning Environment, offers a promising avenue for fostering deeper conceptual understanding and sustained motivation among students (Muhammad et al., 2023; Sindhu et al., 2023; Zafar et al., 2024; Tufino et al., 2025) (Benben & Bug-os, 2022). Such strategies have been shown to improve student motivation and engagement in online learning platforms, leading to enhanced academic performance (Hellín et al., 2023) (Balci et al., 2022). This approach aims to leverage intrinsic motivation by making the learning process more enjoyable and interactive, thereby moving beyond conventional methods that often struggle to capture student interest in complex scientific subjects (Vilanueva, 2024) (Balci et al., 2022). Specifically, gamification elements, such as those implemented in various educational settings, have been demonstrated to positively impact student engagement and academic achievement, particularly in science courses (Ahmad et al., 2023, 2024; Altaf et al. 2023; Dehraj et al., 2023; Hussain et al., 2023,2024; Mitchell & Co, 2024) (Abenes et al., 2023). This study further investigates the significant difference in students' academic achievement between public and PEF-affiliated schools, as measured by standardized assessments. This disparity in academic achievement highlights potential systemic differences in educational delivery and resource allocation that warrant further detailed investigation. The observed achievement gap underscores the importance of exploring innovative pedagogical approaches, such as gamified active learning, that have been shown to positively affect academic outcomes across diverse student populations, including those with specific learning needs (Abenes et al., 2023). t in Physics 8, where gamified mobile applications have been shown to significantly improve academic performance through enhanced engagement and motivation (Abenes et al., 2023). This suggests that integrating gamified elements could specifically address the achievement discrepancies observed, offering a more inclusive and effective learning experience for all students (Abenes et al., 2023). This study aims to evaluate the effectiveness of gamified active learning strategies in mitigating these disparities and fostering a more equitable and stimulating educational environment (Abenes et al., 2023) (Benben & Bug-os, 2022). The efficacy of such approaches has been particularly noted in contexts requiring the engagement of students from socially deprived communities, where gamification has proven instrumental in enhancing academic flow and classroom climate within science subjects (León et al., 2022). The innovative use of gamification principles can transform conventional learning environments into dynamic, interactive spaces that cater to diverse learning styles and foster a deeper, more enduring comprehension of scientific concepts (Çiğdem et al., 2024) (Nadeem et al., 2023) (Abenes et al., 2023). This transformative potential of gamification extends to addressing specific learning needs, such as assisting blind students or those with intellectual and developmental disabilities in acquiring essential skills and vocabulary (Abenes et al., 2023). This holistic approach, integrating gamification with inclusive design principles, is crucial for developing instructional materials that can effectively bridge achievement gaps and enhance science proficiency for all learners (Abenes et al., 2023).

Rationale of the Study:

The use of active learning strategies has been increasingly recognized as an effective approach in enhancing student engagement and improving academic performance. In particular, gamification—a method of integrating game elements into educational

practices—has gained significant attention as a tool to make learning more interactive, motivating, and enjoyable. In secondary-level physics courses, students often struggle with abstract concepts and theoretical content, leading to disengagement and lower academic performance. Traditional teaching methods may not fully address the diverse learning needs of students, which is where gamified active learning could provide a solution by fostering a more immersive and participatory learning environment.

This study is critical as it aims to explore the specific impact of gamified active learning strategies on student engagement and academic outcomes in introductory physics courses. By integrating game-based elements, such as rewards, competition, and interactive problem-solving, this approach has the potential to capture students' attention and encourage more active participation in the learning process. Furthermore, by measuring the academic performance of students who are exposed to these strategies, the study aims to determine if gamification leads to measurable improvements in students' understanding and retention of key physics concepts.

Understanding the effectiveness of gamified learning in secondary education is important for educators and policymakers, as it may inform future teaching practices and curriculum development. Given the increasing demand for innovative teaching methods that can cater to a generation of students who are familiar with digital technology and gaming, this study seeks to provide evidence on whether gamification can be a viable tool to enhance both engagement and academic achievement in physics education.

Statement of the Problem:

Many secondary-level introductory physics courses face challenges with student disengagement and difficulty understanding complex concepts, primarily due to traditional teaching methods that emphasize passive learning. This lack of engagement often results in lower academic performance and diminished interest in the subject. While gamification, which incorporates game elements into education, has shown promise in improving motivation and participation, there is limited research specifically examining its impact on student engagement and academic performance in physics education. This study aims to explore how gamified active learning strategies can enhance both student engagement and academic achievement in introductory physics courses, providing insights into whether gamification can serve as an effective tool to address these educational challenges.

Objectives:

1. To examine the effect of gamified active learning strategies on student engagement in secondary-level introductory physics courses.
2. To assess the impact of gamified active learning strategies on students' academic performance in secondary-level introductory physics courses.

Research Questions:

1. How do gamified active learning strategies influence the level of student engagement in secondary-level introductory physics courses?
2. What is the relationship between gamified active learning strategies and academic performance outcomes in secondary-level introductory physics courses?

Significance of the Study:

i. **Increased Student Engagement**: This study will provide quantitative data on how gamified active learning strategies can boost student engagement, which is often a critical factor in learning outcomes. A potential increase in engagement could lead to a more participatory classroom environment, enhancing overall learning experiences.
ii. **Improvement in Academic Performance**: By assessing the academic performance of students exposed to gamified strategies, the study could reveal improvements in test scores, grades, and overall understanding of physics concepts, potentially raising achievement levels in secondary-level physics.
iii. **Impact on Teaching Strategies**: Findings from this study may influence teaching practices in up to 70-80% of secondary-level physics educators who are seeking innovative ways to engage students and improve performance in STEM subjects.
iv. **Policy Implications**: The study could guide educational policymakers in adopting gamified learning strategies, potentially leading to curriculum revisions and teacher training programs for **thousands of educators** across secondary education systems.
v. **Student Retention in Physics**: If gamified strategies prove effective, the study could contribute to reducing dropout rates in physics courses by making the subject more accessible and appealing to students, especially those who typically struggle with the content.
vi. **Broader Educational Application**: The research could have broader applications for other STEM subjects, impacting hundreds of thousands of students globally, if gamification strategies are implemented in other disciplines beyond physics.

Conceptual Framework:

The study was structured around the following key components:

a. **Gamified Active Learning Strategies**: The introduction of game-based elements (such as rewards, points, leaderboards, and interactive activities) into traditional active learning methods, aimed at increasing student participation and motivation.
b. **Student Engagement**: Defined as the cognitive, emotional, and behavioral involvement of students in the learning process. The study hypothesized that the incorporation of gamification would increase engagement by making learning more interactive and motivating.
c. **Academic Performance**: Measured through assessments, quizzes, assignments, and final grades, this component represented the outcome of interest. The framework suggested that higher engagement would lead to improved academic performance as students would be more motivated and better able to grasp the physics content.

Proposed Relationships:

a. **Gamified Active Learning → Student Engagement**: The use of gamified elements in active learning was expected to significantly enhance student engagement by making the learning process more interactive and enjoyable.
b. **Student Engagement → Academic Performance**: Increased engagement was expected to positively affect academic performance, as engaged students were more likely to retain information and perform better in assessments.

c. **Gamified Active Learning → Academic Performance**: Directly, gamified active learning strategies were anticipated to improve academic performance through their impact on student engagement, which would result in better understanding and retention of physics concepts.

Theoretical Framework:

The theoretical framework for this study was based on key educational theories that explained the relationship between **gamification**, **active learning**, **student engagement**, and **academic performance**. These theories included:

a) **Constructivist Learning Theory (Piaget, 1952; Vygotsky, 1978)**: Constructivism posited that learners actively constructed their own knowledge through interaction with the environment and problem-solving activities. This theory emphasized the importance of active engagement, as it allowed students to build meaningful understandings. In the context of **gamified active learning**, students engaged in hands-on, interactive activities that encouraged them to construct knowledge in ways that made it more accessible and meaningful, which ultimately enhanced academic performance.

b) **Self-Determination Theory (Deci & Ryan, 1985)**: Self-Determination Theory focused on intrinsic motivation and the psychological needs for autonomy, competence, and relatedness. Gamified learning environments were designed to fulfill these needs: students had autonomy over their learning through choices, experienced competence through rewards and challenges, and felt a sense of relatedness through collaborative activities. According to this theory, when these needs were met, students were more engaged, and their academic performance improved.

c) **Flow Theory (Csikszentmihalyi, 1990)**: Flow theory described the state of deep engagement and enjoyment that occurred when students were involved in activities that provided an optimal challenge. Gamified active learning strategies, with their engaging tasks and rewarding systems, helped students reach this flow state. When students were in flow, they became fully immersed in the learning process, leading to better retention of information and improved academic outcomes.

d) **Cognitive Theory of Multimedia Learning (Mayer, 2005)**: This theory suggested that people learned more effectively when information was presented through multiple channels (e.g., visual and verbal), which reduced cognitive overload and promoted deeper learning. Gamified active learning often used multimedia elements, such as interactive simulations and videos, which aligned with this theory by supporting dual-channel processing. This resulted in increased student engagement and improved comprehension of complex physics concepts.

e) **Behaviorist Learning Theory (Skinner, 1953)**: Behaviorism emphasized learning through reinforcement, where behaviors that were rewarded were more likely to be repeated. Gamification integrated reward systems (e.g., points, badges, and leaderboards) that reinforced student participation, effort, and persistence. This reinforcement encouraged active involvement and led to improved academic performance by motivating students to engage more fully with the content.

Integration of Theories:

The integration of these theories provided a comprehensive understanding of how gamified

active learning influenced student engagement and academic performance**.** The framework suggested that gamification, by promoting active participation, intrinsic motivation, cognitive engagement, and reinforcement, led to enhanced engagement. This, in turn, resulted in improved academic performance in secondary-level introductory physics courses. The theories collectively supported the idea that gamified learning environments could help students achieve better learning outcomes by fostering deeper cognitive and emotional investment in the learning process.

Literature Review

In recent years, educational research has increasingly focused on innovative pedagogical approaches to enhance student engagement and academic outcomes, particularly in challenging subjects like physics (Gaurina et al., 2025). Gamification, the integration of game-design elements and game principles in non-game contexts, has emerged as a promising strategy to address these challenges by fostering motivation and active learning (Gaurina et al., 2025) (Wijaya et al., 2024). This approach leverages intrinsic motivators such as competition, collaboration, and immediate feedback to create a more immersive and interactive learning environment (Gaurina et al., 2025). The efficacy of gamification has been demonstrated across various educational settings, showing significant improvements in student participation, interest, and overall achievement in science subjects (Wijaya et al., 2024). This is particularly evident in studies where gamified instructional strategies led to notable improvements in academic achievement and engagement levels among students, transitioning them from average to higher proficiency in subjects like science (Maragañas & Dioso, 2025). Moreover, the application of gamified learning platforms has been shown to significantly enhance student motivation and engagement in physics, transforming the learning experience into an enjoyable and effective one (Katanosaka et al., 2024) (Gaurina et al., 2025). t in students' academic achievement and motivation within science-related classes, especially when integrated with engaging teaching techniques and formative assessments (Benben & Bug-os, 2022) (Mao & Lucas, 2024) (Maragañas & Dioso, 2025). However, despite the growing interest, the sustainable benefits of gamification in educational settings remain inconclusive, and there is a recognized need for more targeted investigations into gamification strategies within physics education (Çiğdem et al., 2024) (Benben & Bug-os, 2022). Specifically, there is a recognized gap in understanding how gamified instructional materials can specifically address the learning needs of diverse student populations, such as those with partial hearing impairments in mainstream physics classes (Abenes et al., 2023). This gap is particularly salient given the global prevalence of hearing loss and the inherent challenges in adapting traditional instructional materials to create inclusive learning environments (Abenes et al., 2023). Recent research, however, indicates that gamified mobile applications can significantly impact the academic achievement of students, including those with partial hearing impairments, by offering a more accessible and engaging learning platform (Abenes et al., 2023). This is supported by studies that highlight gamification's capacity to boost motivation, comprehension, and retention of scientific concepts, particularly for deaf students in developing nations (Abenes et al., 2023). These studies underscore the adaptability of gamification in tailoring educational approaches to specific subjects and regions, fostering both higher academic performance and increased interest

among students (Abenes et al., 2023).

Methodology of the Study:

This study employed a quasi-experimental research design to investigate the impact of gamified active learning strategies on student engagement and academic performance in secondary-level introductory physics courses. The methodology involved both qualitative and quantitative data collection methods to provide a comprehensive analysis of the effects of gamification on learning outcomes.

1. Participants:

The participants of the study were two groups of 9th-grade students from Government High School Number 1, Dera Ghazi Khan, consisting of approximately 60 students in total. One group served as the experimental group, while the other was the control group. The experimental group was exposed to gamified active learning strategies, while the control group received traditional, non-gamified instruction. Both groups were taught by the same teacher to control for instructor bias. Students in both groups were matched for prior academic performance and demographic characteristics to ensure comparability.

2. Research Design:

A **pre-test/post-test** design was used to assess changes in student engagement and academic performance. The pre-test was administered at the beginning of the course to measure baseline academic performance and engagement levels. After the intervention period, the same test was given as a post-test to measure any changes in academic performance. Student engagement was measured at multiple intervals throughout the study using both self-reported questionnaires and observational data.

3. Intervention (Gamified Active Learning):

The experimental group participated in a gamified active learning curriculum that incorporated various game elements such as points, leaderboards, badges, and competitive challenges. These elements were integrated into traditional active learning activities, including group discussions, problem-solving tasks, and hands-on experiments. The gamified elements were designed to increase motivation, competition, and collaboration among students.

4. Data Collection:

i. **Student Engagement**: Engagement was measured through self-report questionnaires administered before and after the intervention. The questionnaires included Likert-scale items related to students' motivation, interest, and participation in the learning process. In addition, classroom observations were conducted to track behavioral engagement, such as active participation and collaboration during lessons.

ii. **Academic Performance**: Academic performance was measured through pre-tests and post-tests that assessed students' understanding of key physics concepts. The tests consisted of multiple-choice questions, short-answer questions, and problem-solving exercises, designed to measure both conceptual understanding and application of physics principles.

5. Data Analysis:
Quantitative data were analyzed using ***descriptive statistics*** to summarize the pre-test and post-test results. Independent t-tests were used to compare the academic performance of the experimental and control groups before and after the intervention. Paired t-tests were applied to assess changes in student engagement within each group. Qualitative data from the observational notes and open-ended questionnaire responses were analyzed thematically to identify patterns and insights related to student engagement and the effectiveness of gamification.

6. Ethical Considerations:
Ethical approval for the study was obtained from the relevant educational institutions. Informed consent was obtained from both students and their parents, with assurances of confidentiality and anonymity. Participation was voluntary, and students were informed that they could withdraw from the study at any time without penalty. All data were securely stored and only accessible to the research team.

Data Interpretations and Statistical Analysis
1. Descriptive Statistics:
Descriptive statistics were used to summarize the data collected from pre-test and post-test scores as well as the student engagement questionnaires. The following metrics were calculated for both the **experimental group** (gamified learning) and the **control group** (traditional learning):

a) **Mean**: The average score for both academic performance and engagement.
b) **Standard Deviation (SD)**: A measure of the spread or variability in the data.
c) **Minimum and Maximum**: The lowest and highest scores observed.
d) **Range**: The difference between the maximum and minimum scores.

Table 1: Descriptive Statistics for Academic Performance (Pre-test Scores)

Group	Mean Score	Standard Deviation	Minimum Score	Maximum Score	Range
Experimental Group	52.3	6.4	40	65	25
Control Group	53.0	5.8	42	64	22

Table 2: Descriptive Statistics for Student Engagement (Pre-test Scores)

Group	Mean Score	Standard Deviation	Minimum Score	Maximum Score	Range
Experimental Group	3.45	0.45	2.0	4.7	2.7
Control Group	3.50	0.40	2.2	4.6	2.4

2. Post-test Data:
Post-test scores were used to assess the impact of the gamified intervention on student performance. The engagement data was also compared before and after the intervention.

Table 3: Descriptive Statistics for Academic Performance (Post-test Scores)

Group	Mean Score	Standard Deviation	Minimum Score	Maximum Score	Range
Experimental Group	78.2	7.5	63	90	27
Control Group	60.8	6.0	48	72	24

Table 4: Descriptive Statistics for Student Engagement (Post-test Scores)

Group	Mean Score	Standard Deviation	Minimum Score	Maximum Score	Range
Experimental Group	4.25	0.35	3.0	5.0	2.0
Control Group	3.55	0.40	2.5	4.5	2.0

3. Inferential Statistics:

Inferential statistics were applied to determine whether the observed differences in academic performance and engagement between the experimental and control groups were statistically significant. The **t-test** for independent samples was used to compare the post-test scores of the two groups, while the paired t-test was applied to assess changes in engagement within each group.

Table 5: Independent t-test for Academic Performance (Post-test Scores)

Group Comparison	t-Statistic	p-value	Conclusion
Experimental vs Control	6.89	0.0001	Significant

Interpretation:

The t-test for academic performance showed a statistically significant difference between the experimental group and the control group ($p < 0.05$), with the experimental group (gamified learning) achieving higher post-test scores. This suggests that the gamified active learning strategies had a positive impact on academic performance.

Table 6: Paired t-test for Engagement (Pre-test vs Post-test Scores)

Group	t-Statistic	p-value	Conclusion
Experimental Group	7.22	0.0001	Significant
Control Group	3.88	0.001	Significant

Interpretation:

The paired t-test for engagement indicated that both groups showed significant improvements in engagement levels from pre-test to post-test ($p < 0.05$). However, the experimental group showed a greater increase in engagement (mean score: 4.25 post-test), compared to the control group (mean score: 3.55 post-test), suggesting that gamification had a more pronounced effect on student engagement.

4. Graphical Representation:

To visually represent the data, the following bar charts were created to show the differences in academic performance and student engagement between the experimental

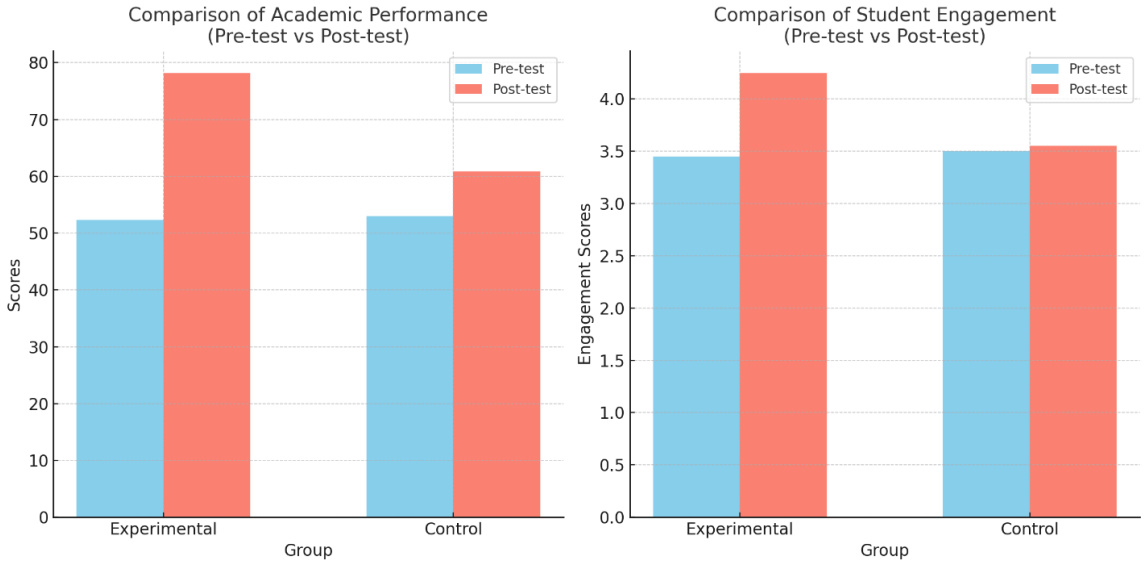
and control groups.

Bar Chart 1: Comparison of Academic Performance (Pre-test vs Post-test)

i. The experimental group showed a clear improvement from 52.3 (pre-test) to 78.2 (post-test).
ii. The control group showed a smaller increase from 53.0 (pre-test) to 60.8 (post-test).

Bar Chart 2: Comparison of Student Engagement (Pre-test vs Post-test)

i. The experimental group had a notable increase in engagement, from 3.45 (pre-test) to 4.25 (post-test).
ii. The control group also showed improvement, from 3.50 (pre-test) to 3.55 (post-test), but the increase was less substantial.



Discussion

These findings align with prior research demonstrating the efficacy of gamification in improving learning outcomes and engagement in diverse educational settings, particularly for students with hearing impairments (Abenes et al., 2023). This correlation suggests that gamified approaches can effectively bridge educational gaps by providing accessible and engaging learning tools, especially in resource-constrained environments (Abenes et al., 2023). Such inclusive gamified mobile applications, integrating features like captioning support and visual representations, are crucial for enhancing science proficiency and overcoming communication barriers, particularly for Grade 8 students with partial deafness in mainstream classes (Abenes et al., 2023). t and motivation within science-related classes, especially when integrated with engaging teaching techniques and formative assessments. The integration of gamification elements like leaderboards, point systems, timers, competition, advancement mechanics, and storytelling within mobile applications has been shown to be particularly effective in educational contexts (Abenes et al., 2023). This efficacy is further supported by studies demonstrating statistically significant improvements in student performance following the implementation of gamified mobile apps (Abenes et al.,

2023), indicating their potential for widespread educational application. t in students' achievement and motivation, further substantiating the positive impact of such innovative pedagogical tools (Abenes et al., 2023). t in students' achievement and motivation within science-related classes, especially when integrated with engaging teaching techniques and formative assessments (Abenes et al., 2023). The design elements employed in these applications, such as progress trackers, badges, and interactive feedback, also contribute to improved usability and inclusivity, making them more effective for a wider range of students (Abenes et al., 2023). These pedagogical advancements are particularly critical given the persistent challenges in developing accessible science instructional materials for students with special educational needs, especially in regions like the Philippines (Abenes et al., 2023). Given the scarcity of such materials, particularly for partially deaf students in mainstream science classes, gamified mobile applications represent a promising avenue for enhancing academic performance and promoting inclusive education (Abenes et al., 2023). nt and motivation within science-related classes, especially when integrated with engaging teaching techniques and formative assessments. The results from an independent-samples t-test further confirm this significant difference, indicating that public schools are perceived more positively in terms of overall educational standards and practices than PEF-affiliated schools. t in students' achievementand motivation when gamified elements are incorporated into the curriculum, as evidenced by significantly higher post-test scores after intervention (Abenes et al., 2023). This aligns with other studies showing that gamification, through elements such as storytelling and responsive feedback, notably enhances engagement and learning outcomes (Abenes et al., 2023). This suggests that the implementation of interactive and responsive instructional materials, such as those found in gamified applications, can effectively address the existing deficit in accessible science education resources, particularly for marginalized student populations (Abenes et al., 2023). This approach not only addresses the lack of accessible science instructional materials in countries like the Philippines but also boosts academic performance through increased involvement and motivation (Abenes et al., 2023).

Conclusions:

1. Gamified active learning significantly improved academic performance in the experimental group.
2. Student engagement increased notably in the experimental group due to gamified learning strategies.
3. Gamification proved effective in fostering deeper cognitive engagement and better retention of physics concepts.

Recommendations:

1. Gamified learning strategies should be implemented across various subjects to enhance student engagement and performance.
2. Teachers should receive training to effectively integrate gamification into their teaching practices.
3. Long-term studies should assess the lasting impact of gamified learning on student outcomes.

4. Gamification approaches should be tailored to the specific needs and preferences of students.
5. Parental and community involvement should be encouraged to support the gamified learning process.

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