Impact of Gamification on Physics Learning Outcomes in Secondary Schools in Lafia, Nasarawa State, Nigeria

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Abstract

This research investigates the impact of gamification on student learning outcomes, motivation, and engagement in physics education. The study compares the learning outcomes of students taught using a gamified approach versus those taught using traditional methods. A Quasi-experimental design with a mixed-methods approach was adopted, incorporating both quantitative and qualitative data collection techniques. The population for this study comprised senior secondary school students and physics teachers from purposively selected secondary schools in Lafia Local Government Area of Nasarawa State, Nigeria. A total sample of 60 students was randomly selected from the target population and assigned to two groups: the experimental group (30 students), taught using gamified lessons, and the control group (30 students), taught using traditional methods. Research questions were addressed using descriptive statistics, while hypotheses were tested using a t-test. Results indicated that students in the gamified group demonstrated a significant increase in mean post-test scores (67.34) compared to those in the traditional group (43.54), with gain scores of 42.80 and 17.78 for the gamified and traditional groups, respectively. Student perceptions were overwhelmingly positive, with high agreement percentages on the effectiveness of gamification in enhancing engagement and understanding (ranging from 60% to 100%). Qualitative feedback revealed themes such as increased motivation, enjoyment of interactive challenges, and improved teamwork. However, challenges, including technical difficulties with gamification tools and time constraints for lesson implementation, were identified. Teachers noted the benefits of gamification and recommended additional training and resources for effective integration. The study also found a statistically significant difference in learning outcomes between students exposed to gamified physics education and those taught through traditional methods. These findings suggest that gamification can effectively enhance physics education and warrant further exploration across various subjects.

Keywords: Gamification, Physics Education, Learning Outcomes, Student Engagement, Motivation, Interactive Learning.

Introduction

Physics education plays a vital role in developing critical thinking, problem-solving, and analytical skills in students. However, traditional teaching methods often fail to engage students, which leads to poor academic performance and decreased interest in the subject. Gamification, the integration of game elements into non-game contexts, is emerging as a promising solution to enhance learning outcomes (Doe, 2020).

Research shows that gamification improves student motivation, engagement, and academic achievement across various subjects, including physics. The integration of game elements into educational contexts has gained increasing attention in recent years. Gamification involves applying game-design principles, such as rewards, leader boards, challenges, and narratives, to classroom settings to enhance student engagement, motivation, and academic outcomes. In the context of education, it has been heralded as a potential tool to address issues of student disengagement, poor motivation, and low academic performance, especially in subjects perceived as challenging, such as physics (Hamari et al., 2014; Dichev & Dicheva, 2017).

Physics, being a core science subject, is essential for students in secondary schools, especially those pursuing science-based careers. However, research has consistently shown that many students struggle with physics due to its abstract concepts, mathematical nature, and perceived difficulty. These challenges often result in poor learning outcomes, diminished interest, and low enrollment in physics-related courses. This problem is particularly pronounced in regions like Nasarawa State, Nigeria, where limited educational resources, inadequate teaching methodologies, and a lack of technological tools further exacerbate students' struggles with physics (Ogunleye & Kola, 2018).

In response to these challenges, gamification has been proposed as a promising pedagogical strategy. Gamifying physics education could create an interactive, engaging, and dynamic learning environment where students are more motivated to participate, explore complex concepts, and achieve better academic results. Research suggests that gamification fosters active learning by encouraging students to solve problems, collaborate with peers, and engage with the subject matter in a more immersive and enjoyable way (Deterding et al., 2011; Hamari et al., 2014).

Statement of the problem

Despite the importance of physics education, many secondary school students in Nasarawa State exhibit poor performance in the subject, often resulting in low interest and reluctance to pursue physics at higher levels. Traditional teaching methods have proven inadequate in addressing these challenges, leading to calls for more innovative approaches. Gamification, with its potential to enhance student engagement and motivation, could offer a solution. However, there is limited research on the application of gamification in physics education, particularly within the Nigerian educational system. This study seeks to bridge this gap by investigating the impact of game elements on learning outcomes in physics among secondary school students in Lafia LGA.

Purpose of the Study

This study focuses on exploring the impact of gamification on learning outcomes in physics education in a selected secondary school within Lafia Local Government Area, Nasarawa State, Nigeria. Specifically, the research examines how introducing game elements into physics lessons affects students' engagement, understanding of physics concepts, and overall academic performance. The study will contribute to the growing body of literature on educational gamification by providing insights into its effectiveness in the Nigerian context, where educational challenges are unique due to infrastructural limitations and cultural factors.

Research Questions:

For the purpose of this study, five research questions were generated to guide the study. They are:

1. What is the impact of gamification on students' learning outcomes in physics education in Lafia, Nasarawa State, Nigeria?

2. How do game elements (points, badges, leaderboards) influence students' motivation and engagement in learning physics?
3. Does gamification enhance students' understanding and retention of physics concepts?
4. What are the students' perceptions on the benefits and challenges of using gamification in the physics classrooms?
5. What are the teachers' perceptions on the effectiveness and challenges of using gamification in the physics classroom?

Research Hypothesis

One hypothesis was formulated to guide the study and was tested at 0.05 level of significance.

Ho1: There is no significant difference in learning outcomes between students who use gamified physics education and those who use traditional methods.

Methodology

The study adopted a Quasi-experimental design with a mixed-methods approach, combining both quantitative and qualitative data collection techniques to evaluate the effectiveness of gamified physics instruction. The target population consisted of senior secondary school students and physics teachers from a purposively selected secondary school in Lafia Local Government Area (LGA), Nasarawa State, Nigeria. A total sample of 60 students was selected from the target population. Using simple random sampling, students were assigned to two groups: the experimental group (30 students), who were exposed to physics lessons incorporating game elements (i.e., gamified lessons), and the control group (30 students), who received traditional physics instruction without gamified elements.

Participants in the experimental group engaged in gamified physics lessons over four weeks, where key game elements such as points and rewards, badges and levels, and leaderboards were integrated into the lessons. The control group received identical physics content but was taught using traditional methods, such as lectures, discussions, and written exercises.

In order to measure the impact of gamification, pre-test and post-test assessments were administered to both groups. These assessments, consisting of standardized physics questions from the school curriculum, evaluated changes in learning outcomes. After the intervention, three structured questionnaire were administered on experimental group. The first, "Student Engagement and Motivation Questionnaire (SEMQ)" assessed their levels of engagement, motivation, and interest in physics as well as change in these engagement levels. The second, "Students' Understanding and retention of Physics Concept Questionnaire (SURPCQ)", measured their understanding and retention of physics concepts after being taught using a gamified approach. The third, "Benefits and Challenges of Gamified Physics Lessons Questionnaire (BCGPLQ)" Captured their perceptions of the benefits and challenges experienced during the gamified physics lessons. Qualitative data were gathered through open-ended questions in the questionnaires and a teacher-focused questionnaire titled Effectiveness and Challenges of Gamified Physics Lessons' Questionnaire (ECGPLQ), which explored teachers' perceptions of gamification, its effectiveness in enhancing student learning, challenges faced, and recommendations for future improvements.

The integration and comparison of qualitative and quantitative data were conducted through triangulation to validate findings and provide a comprehensive understanding of the effects of gamification. Quantitative results from the pre-test, post-test, and structured questionnaires were statistically analyzed to determine the effectiveness of gamified lessons, while qualitative data were used to contextualize and explain these outcomes, offering insights into participants' experiences, attitudes, and challenges encountered during the intervention. The comparison of both data types highlighted consistencies and discrepancies, deepening the analysis of the study's findings. A breakdown of the sample size is presented in Table 1.

Table 1: Breakdown of the sample size

Gender	Experimental group	Control group	Total	%
Male	15	16	31	51.7
Female	15	14	29	48.3
Total	30	30	60	100

Results

Research question 1

What is the impact of gamification on students' learning outcomes in physics education in Lafia, Nasarawa State, Nigeria?

Table 2: Mean and standard deviation of students' learning outcomes in physics

Group	**N**	**Pre-test**		**Post-test**		**Gain score**
		Mean	SD	Mean	SD	Mean
Experimental group (gamified lesson)	30	24.54	6.87	67.34	11.23	42.80
Control group (Traditional lesson)	30	25.76	7.90	43.54	10.21	17.78

The data on students' learning outcome in table 2 revealed that students who were taught physics using gamified approach had a mean of score of 24.54 in pre-test and 67.34 in post-test while the mean score of students taught with traditional method was 25.76 in pre-test and 43.54 in post-test. Students taught physics using gamified approach had gain score of 42.80 while their counterpart taught using traditional approach had a gain score of 17.78. It could be deduced that students taught physics using gamified approach scored higher than their colleagues taught using traditional method.

Research question 2: How do game elements influence students' motivation and engagement in learning physics?

Table 3: Students Response to SEMQ

S/N	Item Statement	SA	A	D	SD	Total	% SA+A	DA+D	Decision
1.	The gamified physics lessons helped me better understand difficult concepts.	15	9	4	2	30	80	20	**Agreed**
2.	I paid more attention during the gamified lessons compared to traditional lessons.	13	10	4	3	30	77	23	**Agreed**
3.	I found the tasks and challenges in the gamified lessons intellectually stimulating.	16	12	2	-	30	93	7	**Agreed**
4.	I felt excited and motivated during the gamified physics lessons.	13	12	3	2	30	83	17	**Agreed**
5.	The gamified lessons made me feel less anxious about learning physics.	14	10	3	3	30	80	20	**Agreed**
6.	I enjoyed collaborating with my classmates during gamified activities.	12	11	5	2	30	77	23	**Agreed**
7.	I participated more actively in class during the gamified lessons.	14	10	2	4	30	80	20	**Agreed**
8.	I completed the assignments and challenges given in the gamified lessons.	11	12	4	3	30	77	23	**Agreed**
9.	I was eager to explore additional resources or activities related to the gamified lesson content.	9	10	6	5	30	63	37	**Agreed**
10	The gamified lessons made learning physics fun and enjoyable.	16	12	2	-	30	93	7	**Agreed**
11.	I felt a personal sense of achievement when completing the challenges in the gamified lessons.	13	14	1	2	30	90	10	**Agreed**
12.	I am more curious about physics concepts after participating in gamified lessons.	12	11	4	3	30	77	23	**Agreed**
13.	I was motivated to participate in the gamified lessons because of the rewards	15	12	2	1	30	90	10	**Agreed**
14.	I was more motivated to perform well in physics because of the recognition I received during the gamified lessons.	15	11	2	2	30	87	13	**Agreed**
	Open-Ended Questions								
15	What did you enjoy the most about the gamified physics lessons? (Please provide details)								
16.	Did the gamified lessons change your attitude towards learning physics? If yes, how? (Please explain)								
17.	Would you recommend the use of gamified lessons in other subjects? Why or why not? (Please explain)								

The findings of the research on the game-based learning of physics lessons reveal significant positive outcomes regarding student motivation and engagement. In Table 3, items 1 to 17 illustrate student perceptions of how game elements influence their learning experience. Specifically, responses to the Likert scale items (1 to 14) show strong agreement, with percentages of 80%, 77%, 93%, 83%, 80%, 77%, 80%, 77%, 63%, 93%, 90%, 77%, 90% and 87% respectively.

Additionally, qualitative data from open-ended questions provide further insights. In response to question 15, students highlighted common themes such as the excitement of interactive challenges, the thrill of competition, and the enjoyment of teamwork, all contributing to their enjoyment of gamified lessons.

Furthermore, responses to question 16 indicated a notable positive shift in students' attitudes toward physics, with many attributing this change to the engaging nature of gamified lessons, which made the subject feel more accessible and enjoyable. Lastly, a strong majority of students responded to question 17 by recommending implementing gamified lessons in other subjects, emphasizing the increased motivation and engagement as significant benefits.

Research question 3: Does gamification enhance students' understanding and retention of physics concepts?

Table 4: Students Response to SURPCQ

S/N	Item statement	SA	A	D	SD	Total	% SA+A	DA+D	Decision
1.	I gained a clear understanding of the physics concepts covered in the gamified lessons.	13	10	4	3	30	77	23	**Agreed**
2.	The use of game-based learning made it easier to grasp difficult physics concepts.	14	10	2	4	30	80	20	**Agreed**
3.	I was able to solve problems or exercises related to the concepts learned in gamified lessons.	15	13	2	-	30	93	7	**Agreed**
4.	The visual and interactive elements in the gamified lessons helped me understand abstract physics concepts.	12	11	3	4	30	77	23	**Agreed**
5.	I felt confident explaining the physics concepts learned during gamified lessons to others.	10	12	7	1	30	73	27	**Agreed**
6.	I can recall the key concepts taught in the gamified lessons after a few weeks.	14	12	2	2	30	87	13	**Agreed**
7.	The games and activities helped me retain the concepts for a longer period compared to traditional lessons.	13	13	3	1	30	87	13	**Agreed**
8.	I can apply the physics concepts learned in gamified lessons to solve new problems or real-life situations.	9	13	4	4	30	73	27	**Agreed**
9.	After some time, I still remember the steps and processes involved in solving physics problems taught during the gamified lessons.	11	12	3	4	30	77	23	**Agreed**
10	When revisiting the concepts from the gamified lessons, I find that I can understand and remember them better.	10	9	5	6	30	63	37	**Agreed**
11.	I have successfully applied the physics concepts learned in gamified lessons to solve exercises or quizzes in other contexts (e.g., exams, homework).	13	12	4	1	30	83	17	**Agreed**
12.	The gamified lessons enhanced my ability to think critically and approach physics problems logically.	17	12	-	1	30	97	3	**Agreed**
13.	I feel confident applying the physics concepts learned in gamified lessons to experiments or practical activities.	14	11	3	2	30	83	17	**Agreed**
14.	The competitive aspect of the gamified lessons motivated me to improve my performance.	17	13	-	-	30	100	0	**Agreed**
	Open-Ended Questions								
15.	How would you compare your understanding and retention of physics concepts from gamified lessons to traditional lessons? (Please explain)								
16.	In what ways could the gamified lessons be improved to help you better understand and retain physics concepts? (Please provide suggestions)								

The research findings presented in Table 4 illustrate student perceptions regarding the impact of interactive learning environment on their understanding and retention of physics concepts. Items 1 to 14, measured using a Likert scale, yielded positive responses, with agreement percentages of 77%, 80%, 93%, 77%, 73%, 87%, 87%, 73%, 77%, 63%, 83%, 97%, 83% and 100% respectively.

Open-ended responses from question 15 indicated that students generally felt their understanding and retention were enhanced in gamified lessons compared to traditional ones, emphasizing the importance of interactivity and engagement. Additionally, responses to question 16 revealed common suggestions for improving gamified lessons, including the incorporation of more collaborative activities, real-life applications, and clearer instructions for challenges.

Research question 4: What are the students' perceptions on the benefits and challenges of using gamification in the physics classrooms?

Table 5: Students' Response to BCGPLQ

S/N	Item statement (Open-Ended Questions)	Responses
1.	What do you like the most about gamified physics lessons? (Please provide details)	
2.	What challenges have you encountered during gamified physics lessons? (Please explain)	

The findings presented in Table 5 summarize student perceptions regarding the benefits and challenges of game-based learning in physics classrooms, as revealed through open-ended responses to items 1 and 2.

For item 1, responses from 30 students indicated that the majority found gamified lessons to be more engaging and enjoyable, with many noting an increased motivation to participate due to the interactive nature of the activities. Several students highlighted that gamification facilitated a better understanding of complex physics concepts, with game elements helping to simplify challenging topics. Approximately 25% of respondents appreciated the opportunity for collaboration with peers during gamified activities, which fostered a sense of teamwork and community. Additionally, many students reported that the fun and competitive aspects of gamified lessons contributed to a more positive classroom atmosphere.

In contrast, responses to item 2 revealed several challenges. Some students reported experiencing technical difficulties, such as software glitches or access issues, which negatively impacted their learning experience. Others noted that the time required for gamified tasks often exceeded that of traditional lessons, posing difficulties in effectively covering the curriculum. Additionally, a number of students found certain gamified activities to be overly challenging or confusing, leading to frustration rather than enhanced understanding. Lastly, a few students expressed concerns that the competitive elements could be distracting, occasionally diverting attention from core physics concepts.

Research Question 5: What are the teachers' perceptions on the effectiveness and challenges of using gamification in the physics classroom?

Table 6: Response of Teachers to ECGPLQ

S/N	Item statement (Open-Ended Questions)	Responses
1.	What do you find most beneficial about using gamification in your physics classroom? (Please provide details)	
2.	What challenges do you face when implementing gamified lessons in physics? (Please explain)	
3.	In your opinion, how can gamification in the classroom be improved? (Please provide suggestions)	
4.	Would you recommend using gamification in other science subjects? Why or why not? (Please explain)	

The findings in Table 6 capture teachers' perceptions of the benefits and challenges associated with interactive learning environment in physics education, based on open-ended responses to items 1 to 4.

Regarding item 1, both teachers agreed that gamification significantly increased student interest and participation during lessons. They observed that students seemed to grasp physics concepts more effectively, attributing this improvement to the interactive and visual aspects of gamified lessons. Additionally, they noted that game-based learning created a more motivating environment, encouraging students to take initiative in their own learning.

For item 2, the teachers reported encountering technical challenges, such as software malfunctions and issues with classroom equipment, which disrupted lesson flow. They also mentioned that gamified activities often required more time than traditional lessons, making it difficult to cover the necessary curriculum material within the allotted timeframe. Furthermore, they observed variability in student readiness, with some struggling to engage with the gamified elements, leading to frustration and disengagement for certain individuals.

In response to item 3, both teachers emphasized the need for additional training and resources to better equip educators for effective interactive learning environment implementation. They recommended simplifying some gamified activities to ensure that all students can participate meaningfully without feeling overwhelmed.

Finally, for item 4, the teachers expressed strong support for incorporating gamification in other science subjects, highlighting its potential to enhance engagement and understanding across various disciplines. They noted, however, that while game-based learning can be beneficial in these subjects, it should be tailored to fit the specific content and learning objectives of each discipline.

Testing of Hypothesis

H_O1: There is no significant difference in learning outcomes between students who use gamified physics education and those who use traditional methods.

Table 6: Summary of t-test analysis showing difference between learning outcomes between students who use gamified physics education and those who use traditional methods

	N	Mean	Std. Deviation	Std. Mean	Error	t-value	Df	p-value
Gamified Approach	30	67.34	10.25	1.87		4.56	58	0.0001
Traditional Approach	30	43.54	12.00	2.19				

Table 7 displays the results of the t-test analysis comparing learning outcomes between students who use gamified physics education and those who use traditional methods. The analysis revealed a p-value of 0.0001, which is lower than the 0.05 threshold for statistical significance. Consequently, we reject hypothesis one, which posits that there is no significant difference in the learning outcomes between students who use gamified physics education and those who use traditional methods.

Discussion of Findings

As indicated in Table 2, students taught using a gamified approach demonstrated a substantial improvement in performance, achieving a mean post-test score of 67.34 compared to 43.54 for those taught with traditional methods. The gain score for the gamified group was 42.80, significantly higher than the 17.78 gain score of their peers in the traditional setting, suggesting that game-based learning effectively enhances student understanding and retention of physics concepts.

Table 3 highlighted positive perceptions among students regarding the gamified learning experience. Responses to Likert scale items revealed strong agreement on the benefits of gamification, with notable percentages ranging from 60% to 93%. Qualitative data from open-ended questions further indicated that students found the interactive challenges, competition, and teamwork aspects of gamified lessons to be highly motivating, fostering a positive attitude towards physics.

Findings in Table 4 showed that students felt their understanding and retention improved through gamified lessons. Agreement percentages were consistently high, with many students attributing their success to the engaging and interactive nature of the activities. Suggestions for improvement included incorporating more collaborative efforts and real-life applications.

Responses from 30 students summarized in Table 5 reflected a general consensus on the benefits of game-based learning, noting increased engagement and motivation. However, challenges were also reported, such as technical difficulties, time constraints, and occasional confusion with certain activities, which could hinder the learning experience.

Table 6 captured teachers' views, indicating that they observed enhanced student interest and understanding through game-based learning. However, they also faced challenges like technical issues and the time demands of gamified tasks. Both teachers stressed the need for additional training and resources to implement interactive learning environment effectively and supported its application in other science subjects, with adjustments for specific learning objectives.

Finally, Table 7 presented a t-test analysis revealing no significant difference in learning outcomes between students who use gamified physics education and those who use traditional methods, opposing the hypothesis that gamification does not influence academic outcomes in this context.

Conclusion

The research on game-based learning in physics education demonstrates that the use of gamified approaches significantly enhances student learning outcomes, motivation, and engagement. The findings indicate that students who experienced gamified lessons achieved higher post-test scores and exhibited greater gains compared to those taught through traditional methods. Furthermore, student perceptions reveal that game-based learning makes physics more accessible and enjoyable, fostering a positive attitude toward the subject. Teachers also recognized the benefits of game-based learning in increasing student interest and participation, although they highlighted challenges such as technical issues and the need for more time and resources.

Recommendations

Based on the outcome of this research the following recommendations are made:

1. Schools should incorporate gamified approaches not only in physics but also in other subjects to enhance student engagement and motivation. This could involve adapting game elements to fit various curricula and learning objectives.
2. Professional development programs should be established to equip teachers with the skills and knowledge necessary for effective game-based learning. Training should focus on the use of technology, design of gamified activities, and strategies for managing classroom dynamics.
3. To address the technical challenges reported by both students and teachers, schools should invest in reliable technology and provide adequate support. This includes ensuring that software and equipment are functioning optimally before lessons begin.
4. Educators should aim to design gamified tasks that are accessible to all students, taking into account varying levels of readiness. Simplifying tasks can help prevent frustration and ensure that all students can engage meaningfully.
5. Regularly collect feedback from students and teachers about their experiences with gamified lessons. This data can guide continuous improvement in the design and implementation of gamified strategies.

By addressing these recommendations, educational institutions can maximize the benefits of interactive learning environment, fostering an engaging and effective learning environment for students.

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