Use of Gamification-Based Teaching Strategies in Enhancing Students' Academic Performance in Basic Science in Rivers State, Nigeria

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Abstract

This study investigated the use of gamification-based teaching strategies in enhancing students' academic performance in Basic Science in Rivers State, Nigeria. The study was guided by two research questions and two corresponding null hypotheses tested at the 0.05 level of significance. A pretest–posttest control group quasi-experimental research design was adopted. The population comprised 3,120 Junior Secondary School Two (JSS2) students from 35 registered private secondary schools in Port Harcourt. A sample of 112 students was selected using a combination of simple random and purposive sampling techniques. Two schools were randomly selected, while intact classes were used, and schools were purposively chosen based on criteria such as availability of ICT facilities, presence of qualified Basic Science teachers, co-educational structure, and administrative consent. Data were collected using a researcher-developed Basic Science Performance Test (BSPT), which was validated by experts and yielded a reliability coefficient of 0.82 using the Kuder-Richardson 21 formula. The experimental group was exposed to gamification-based instruction involving points, badges, leaderboards, quizzes, and progressive challenges, while the control group was taught using the demonstration method. Data were analyzed using mean, standard deviation, and Analysis of Covariance (ANCOVA) to control for pre-existing differences. Findings revealed that students taught using gamification-based strategies performed significantly better than those taught using the demonstration method. The results also showed no significant difference between male and female students' academic performance when exposed to gamification. The study concludes that gamification enhances students' engagement, motivation, and academic performance in Basic Science. It recommends that teachers integrate gamification strategies into classroom instruction and that school administrators provide the necessary training and resources to support its implementation.

Keywords: Gamification-based teaching, Academic performance, Basic Science, Instructional strategies

Introduction

The scientific and technological progress of any nation is fundamentally anchored in the quality of its educational system, particularly science education at the basic level. Education serves as a structured process through which learners acquire knowledge, develop cognitive and psychomotor skills, internalize values, and cultivate the critical and creative thinking abilities necessary for personal and societal development. Basic Science, as a foundational subject, plays an essential role in nurturing scientific literacy, problem-solving capacity, and innovation skills required for national development. However, persistent challenges such as declining interest in science, passive learning environments, and poor academic performance continue to stand as a barrier to the effectiveness of Basic Science instruction in many developing countries, including Nigeria (Adeoye, 2023). In response to these challenges, educational technology has emerged as a critical driver of pedagogical transformation. Educational technology offers innovative tools and strategies that can enhance learner engagement, motivation, and academic achievement across diverse learning environments. Among these emerging strategies, gamification has attracted increasing scholarly attention as a means of reducing classroom boredom, stimulating learner motivation, and boosting academic performance in science-related subjects (Ginna et al., 2025). Gamification represents a pedagogical shift from teacher-centered instruction to learner-centered, interactive, and motivational learning experiences.

Gamification is defined as the deliberate integration of game design elements into non-game instructional contexts to motivate learners and enhance engagement, persistence, and performance. Unlike full-scale educational games, gamification incorporates specific game mechanics, including points, badges, leaderboards, levels, challenges, narratives, progress bars, and rewards, into existing curricular activities (Dikman, 2021).

These elements leverage learners' intrinsic tendencies toward competition, achievement, curiosity, and mastery, thereby encouraging sustained involvement in learning tasks. From an educational psychology perspective, gamification is grounded in motivational theories that emphasize prompt feedback, goal orientation, reinforcement, and self-regulation. By structuring learning tasks as progressive challenges with visible achievements, gamification transforms students from passive recipients of knowledge into active participants in a continuous cycle of exploration, feedback, and mastery (Dikman, 2021). This shift is particularly valuable in science education, where abstract concepts often require sustained cognitive engagement and repeated practice. Empirical research further suggests that gamification strategies are highly context-dependent and must be carefully aligned with curricular goals and pedagogical intentions. Adaptive gamification environments designed to support inquiry-based and problem-based learning in science have been shown to significantly enhance students' conceptual understanding and knowledge retention compared with traditional instructional approaches (Zourmpakis et al., 2024). These environments typically integrate structured feedback loops, tiered challenges, collaborative tasks, and progress-tracking systems, all of which promote accountability, deeper cognitive processing, and meaningful learning experiences (Lee et al.,2020).

Academic performance in Basic Science is commonly assessed through students' mastery of scientific concepts, problem-solving abilities, and retention of learned knowledge. These indicators collectively reflect the level of scientific literacy attained by learners at the foundational stage. However, traditional Basic Science instruction in many Nigerian secondary schools remains largely lecture-based, emphasizing rote memorization rather than conceptual understanding and application. Such approaches often fail to stimulate students' intrinsic motivation, resulting in poor academic outcomes and negative attitudes toward science learning (Adeoye, 2023). In contrast, gamification-based instructional strategies have demonstrated considerable potential for improving students' academic performance in science subjects. Studies conducted in junior secondary school contexts reveal that students exposed to gamified instructional packages consistently achieve higher post-test scores in Basic Science and Technology than their counterparts taught using conventional teaching methods (Abidoye & Abidoye, 2022). These findings suggest that gamification enhances both the cognitive and affective dimensions of learning, which are essential for academic success. The effectiveness of gamification in improving academic performance can be attributed to its multifaceted mechanisms. Cognitively, gamification structures learning tasks as progressive challenges with clear performance benchmarks, thereby facilitating deeper processing, encoding, and retrieval of scientific concepts during assessments. Affectively, real-time feedback, rewards, and recognition foster motivation, persistence, and positive learning attitudes, which mediate sustained engagement and improved achievement outcomes (Ginna et al., 2025).

In the context of Basic Science, gamification offers significant instructional advantages. Science concepts often involve abstract processes, experimentation, and scientific reasoning that students find difficult to comprehend through conventional lecture-based approaches. Gamified instructional strategies can convert these abstract concepts into interactive and meaningful learning experiences by encouraging exploration, collaboration, experimentation, and immediate feedback (Nwachukwu & Johnson, 2020). Through digital quizzes, simulations, challenges, and reward systems, learners are more likely to engage actively with scientific content, practice problem-solving skills, and develop positive attitudes toward science learning. Recent empirical studies provide mixed but insightful evidence on the effectiveness of gamification. While several studies report significant improvements in academic achievement following gamified interventions (Arufe Giráldez et al., 2021; Kladchuen & Srisomphan, 2021), others indicate non-significant effects, often attributed to learners' unfamiliarity with gamification protocols or poor instructional design (Mee-Mee et al., 2020). These inconsistencies underscore the need for context-specific investigations that account for pedagogical implementation, learner characteristics, and instructional environments.

Gender is another important variable influencing the effectiveness of technology-enhanced instructional strategies. Gender refers to the socially and culturally constructed roles, behaviors, and expectations associated with males and females within a given society (Aderele & Abidoye, 2022). Research suggests that gender differences may shape learners' engagement with technology-based instruction, including gamified learning environments. However, evidence regarding gender differences in gamification outcomes remains inconclusive. Some studies report minimal or non-significant differences between male and female students' academic performance in gamified science classrooms (Abidoye & Abidoye, 2022), while others suggest that adaptive gamification approaches may differentially benefit female learners by providing supportive, low-risk environments for participation and mastery (Zourmpakis et al., 2024). These findings highlight the importance of examining gender as a moderating variable in gamification research. Abidoye and Ogundare (2024) revealed that students taught using gamification-based instructional packages performed significantly better than those taught with conventional methods. Importantly, the study also found no significant difference in the academic achievement of male and female students exposed to gamified instruction, suggesting that gamification may provide an equitable learning platform across gender lines.

Despite the growing global body of literature on gamification in education, its application in Nigerian secondary schools, particularly in Rivers State, remains limited. Challenges such as overcrowded classrooms, inadequate instructional resources, and declining student interest in science subjects continue to affect learning outcomes. Moreover, there is a scarcity of context-specific empirical studies examining how gamification-based instructional strategies influence students' academic performance in Basic Science within Rivers State. Against this backdrop, the present study investigates the use of gamification-based teaching strategies in enhancing students' academic performance in Basic Science in Rivers State, Nigeria

Statement of the problem

Basic Science is a critical subject that equips students with foundational scientific knowledge, problem-solving skills, and the ability to apply concepts in everyday life. Ideally, teaching should engage students, stimulate curiosity, and enhance academic performance. However, in many secondary schools in Rivers State, instruction is predominantly teacher-centered and lecture-based, leading to low motivation, limited participation, and poor understanding of scientific concepts. Many students struggle to grasp abstract scientific concepts due to the limited integration of interactive and technology-enhanced teaching strategies. Gamification, which incorporates game elements such as points, badges, leaderboards, and challenges, has the potential to create engaging and motivating learning experiences. The purpose of this study, therefore, is to investigate the use of gamification-based teaching strategies in enhancing students' academic performance in Basic Science, providing evidence-based recommendations for improving instructional practices in Rivers State secondary schools

Aim and Objectives of the Study

The aim of this study is to investigate the use of gamification-based teaching strategies in enhancing students' academic performance in basic science in Rivers State, Nigeria. Specifically, the study intends to

1. compare the academic performance of students taught Basic Science using gamification-based instructional strategy and those taught using a demonstration instructional strategy
2. Determine whether there is a significant difference between male and female students' academic performance that were taught Basic Science using gamification-based instructional strategy

Research Questions

1. What difference exists in the academic performance of students taught Basic Science using a gamification-based instructional strategy and those taught using a demonstration instructional strategy?
2. What is the difference between male and female students' academic performance taught Basic Science using gamification-based instructional strategy?

Research Hypotheses

The following null hypotheses were tested at the 0.05 level of significance

1. There is no significant difference in the academic performance of students taught Basic Science using a gamification-based instructional strategy and those taught using a demonstration instructional strategy.
2. There is no significant difference between male and female students' academic performance taught Basic Science using gamification-based instructional strategy.

Methodology

This study adopted a pretest-posttest, control group quasi-experimental research design. The population for this study comprised 3,120 Junior Secondary School 2 (JSS2) students across all 35 registered private junior secondary schools in Port Harcourt, Rivers State. These schools were selected for their registration with the Rivers State Ministry of Education and their active Basic Science programs. The focus on JSS2 students was due to the level's alignment with the teaching of foundational Basic Science concepts relevant to assessing academic performance.

The sample for the study consisted of 112 JSS2 students drawn from two intact classes in each of the two private junior secondary schools randomly selected from the list of private schools in Port Harcourt metropolis. The schools were also purposively selected based on specific criteria: they were co-educational, ensuring gender representation; they employed at least one professional Basic Science teacher with a B. Ed or B. Sc (Ed) qualification; they were well-equipped with ICT facilities suitable for gamification-based instruction; they were accessible within Port Harcourt to facilitate supervision; and the school administration provided consent for participation. This sampling approach ensured that the selected schools provided the necessary resources and environment to implement gamification effectively. The research instrument used for data collection was a researcher-developed Basic Science Performance Test (BSPT). The BSPT was validated by experts in Science Education and Educational Technology, yielding a reliability coefficient of 0.82 using the Kuder Richardson-21 (KR-21) formula. The instrument consisted of two sections: Section A captured respondents' biodata, while Section B contained 50 multiple-choice questions covering topics such as Ecosystem, Safety in the Laboratory, Cells and Tissues, Force and Motion, and Matter. Each correct answer attracted 2 marks, while incorrect answers scored zero, giving a maximum obtainable score of 100%. The BSPT was designed to measure students' academic performance in Basic Science.

Data collection was conducted in three stages. First, the researcher identified the sampled schools and obtained permission from the principals. Professional Basic Science teachers from the selected schools were trained to serve as research assistants during the study. In the second stage, the BSPT was administered as a pre-test to all sampled students to establish baseline academic performance. The students were then taught for four weeks, with the experimental group receiving gamification-based instruction, incorporating points, badges, leaderboards, quizzes, and progressive challenges, while the control group received conventional teaching methods. In the third stage, the BSPT was re-administered as a post-test to measure the students' academic performance after the intervention. The research assistants collected the completed scripts under the researcher's supervision, after which the researcher marked, graded, and recorded the scores.

The data obtained from the pre-test and post-test formed the basis for analysis. Descriptive statistics, including mean and standard deviation, were used to answer the research questions on students' academic performance, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at a 0.05 level of significance. ANCOVA was selected to control for pre-existing differences in students' academic ability, allowing for a precise determination of the effect of gamification-based teaching strategies on students' academic performance in Basic Science.

Results

Research Question 1: What difference exists in the academic performance of students taught Basic Science using a gamification-based instructional strategy and those taught using a demonstration instructional strategy?

Table 1: Mean and standard deviation of students' performance based on methods

Methods		Pretest	Posttest	Mean gain
Gamification	Mean	40.4815	71.8889	31.4074
	N	54	54	54
	Std. Deviation	6.21544	6.12347	7.98706
Demonstration	Mean	40.2759	49.3793	9.1034
	N	58	58	58
	Std. Deviation	4.04272	7.40040	7.58736

Table 1 shows that the gamification group had a pretest mean score of 40.48, which increased to a posttest mean score of 71.89, resulting in a mean gain of 31.41. In contrast, the demonstration group recorded a pretest mean score of 40.28 and a posttest mean score of 49.38, with a mean gain of 9.10. This suggests that students taught using gamification-based teaching strategies showed greater improvement in academic performance compared to those taught using the demonstration method.

Research Question 2: What is the difference between male and female students' academic performance taught Basic Science using gamification-based instructional strategy?

Table 2: Mean and standard deviation of students' performance based on gender

Gender		Pretest	Posttest	Mean gain
Male	Mean	40.3836	60.8493	20.4658
	N	73	73	73
	Std. Deviation	5.46359	12.44953	12.55884
Female	Mean	40.3590	59.0769	18.7179
	N	39	39	39
	Std. Deviation	4.67630	14.54464	15.50882

Table 2 shows that male students recorded a pretest mean score of 40.38, which increased to a posttest mean score of 60.85, resulting in a mean gain of 20.47. Similarly, female students had a pretest mean score of 40.36 and a posttest mean score of 59.08, with a mean gain of 18.72. The results indicate that both male and female students improved in academic performance, with male students showing a slightly higher mean gain than female students.

Hypothesis 1: There is no significant difference in the academic performance of students taught Basic Science using a gamification-based instructional strategy and those taught using a demonstration instructional strategy.

Table 3: ANCOVA Analysis of gamification-based instructional strategy and demonstration instructional strategy on students' performance in Basic Science

Tests of Between-Subjects Effects

Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14339.537[a]	2	7169.768	158.250	.000	.744
Intercept	4671.007	1	4671.007	103.098	.000	.486
Pretest	170.561	1	170.561	3.765	.055	.033
Methods	14101.508	1	14101.508	311.246	.000	.741
Error	4938.428	109	45.307			
Total	425604.000	112				
Corrected Total	19277.964	111				

a. R Squared = .744 (Adjusted R Squared = .739)

Table 3 shows that after controlling for students' pretest scores, there was a statistically significant effect of instructional method on students' posttest performance in Basic Science, $F(1, 109) = 311.246$, $p = .000$ ($p < .05$). This result indicates a significant difference in the academic performance of students taught using the gamification-based instructional strategy and those taught using the demonstration instructional strategy. The Partial Eta Squared value of .741 indicates a very large effect size, suggesting that the instructional method accounted for a substantial proportion of the variance in students' posttest performance in Basic Science.

Hypothesis 2: There is no significant difference between male and female students' academic performance taught Basic Science using gamification-based instructional strategy.

Table 4: ANCOVA analysis of male and female students' performance in Basic Science

Tests of Between-Subjects Effects

Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	317.257[a]	2	158.628	.912	.405	.016
Intercept	4237.193	1	4237.193	24.358	.000	.183
Pretest	237.404	1	237.404	1.365	.245	.012
Gender	79.228	1	79.228	.455	.501	.004
Error	18960.707	109	173.951			
Total	425604.000	112				
Corrected Total	19277.964	111				

a. R Squared = .016 (Adjusted R Squared = -.002)

Table 4 shows that after controlling for students' pretest scores, there was no statistically significant effect of gender on students' posttest performance in Basic Science, $F(1, 109) = 0.455$, $p = .501$ ($p > .05$). This indicates that male and female students did not differ significantly in their academic performance after the intervention. The Partial Eta Squared value of .004 suggests a very small effect size, indicating that gender accounted for a negligible proportion of the variance in students' posttest performance.

Discussion of Results

The findings of this study in Table 1 indicated that gamification-based teaching strategies enhanced students' academic performance in Basic Science. Students taught using gamification showed considerably greater improvement in posttest scores compared to those taught with the demonstration method, suggesting that gamification effectively promoted engagement, motivation, and understanding of scientific concepts. The analysis in Table 3 further showed that the difference in performance between the two instructional groups was significant even after accounting for initial differences in pretest scores. This confirms that the improvement observed in the gamification group was due to the instructional strategy rather than prior knowledge, highlighting the effectiveness of gamification in enhancing learning outcomes.

These results align with previous research showing that adaptive gamification environments, especially those supporting inquiry-based and problem-based learning, improve students' conceptual understanding and knowledge retention compared with traditional instructional approaches (Zourmpakis et al., 2024). Studies in junior secondary schools similarly report that students exposed to gamified instructional packages achieve higher post-test scores in Basic Science and Technology than those taught using conventional methods (Abidoye & Abidoye, 2022). While some research indicates mixed outcomes due to factors such as unfamiliarity with gamification protocols or poor instructional design (Mee-Mee et al., 2020), the overall evidence supports the positive impact of gamification on academic achievement (Arufe Giráldez et al., 2021; Kladchuen & Srisomphan, 2021).

The findings of Table 2 indicate that both male and female students improved in academic performance in Basic Science following exposure to gamification-based teaching strategies. Male students recorded slightly higher gains than female students, but the difference was minimal. The analysis of Table 4 further showed that after accounting for pretest scores, gender did not have a statistically significant effect on posttest performance. This suggests that male and female students benefited similarly from gamified instruction and that the differences in gains were negligible. The results indicate that gamification-based strategies provide an equitable learning environment that supports both genders effectively.

These findings are consistent with previous research. Some studies report minimal or non-significant differences between male and female students in gamified science classrooms (Abidoye & Abidoye, 2022), while others suggest that adaptive gamification approaches may particularly support female learners by offering low-risk, motivating environments for participation and mastery (Zourmpakis et al., 2024). Similarly, Abidoye and Ogundare (2024) found no significant difference in the academic achievement of male and female students exposed to gamified instruction, reinforcing the idea that gamification can provide an inclusive platform for all learners.

Conclusion

The study concludes that gamification-based teaching strategies significantly enhance students' academic performance in Basic Science compared to conventional demonstration methods. Both male and female students benefited from gamified instruction, with no significant gender differences in post-intervention performance, indicating that gamification provides an equitable learning environment. The findings underscore the effectiveness of gamification in promoting engagement, motivation, and conceptual understanding in Basic Science.

Recommendations

Based on the findings of this study, the following recommendations were made to improve Basic Science teaching and learning in secondary schools:

1. Basic Science teachers in secondary schools should integrate gamification-based strategies into their instructional practices to improve students' learning outcomes.
2. School administrators and policymakers should provide professional development and training for teachers on effective gamification techniques.
3. Educational technology resources, including gamified learning platforms and tools, should be made available and accessible in schools to support interactive and engaging learning experiences.
4. Further research should explore the long-term impact of gamification on students' academic performance and investigate its effectiveness across other science subjects and educational levels.

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