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Effect of Game-Based Learning Platforms on Senior Secondary Student Engagement and Knowledge Retention in Biology in Kwara State, Nigeria

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Abstract

The study investigated the Effect of Game-based Learning Platforms on Senior Secondary Student's engagement and Knowledge Retention in Biology in Kwara State, Nigeria**.** Utilizing a quasi-experimental design, the research involved two groups: an experimental group exposed to classroom based gamified learning strategies and a control group receiving traditional lecture-based instruction. Data were collected using a Biology Achievement Test (BAT) and a Student Engagement Questionnaire (SEQ), with high reliability. The findings indicated that gamification significantly enhances student engagement and knowledge retention, addressing the challenges of low engagement and poor academic outcomes prevalent in the State The study underscores the importance of adopting innovative teaching strategies in resource-constrained settings, providing empirical evidence that supports the integration of gamification into the biology curriculum. This study contributed to the broader knowledge on educational strategies that foster active learning and intrinsic motivation among students. The study recommended that schools should incorporate gamified learning strategies into the biology curriculum to enhance student engagement and improve academic performance. Teachers should be trained and retrained by school management and government on gamification techniques to effectively implement these strategies in the classroom in order to ensure a more interactive learning environment.

Introduction

Education is the foundation and vehicle for societal progress. Improving the quality of teaching has become critical to meet the evolving needs of 21st-century learners. Among the various innovative teaching strategies being adopted, gamification has emerged as a promising method to enhance learning outcomes. Gamification involves the integration of game activities, such as competition, rewards, and role-playing, into non-game contexts, including education Deterding, Dixon, Khaled, & Nacke, (2011) In the classroom, gamification transforms traditional teaching methods into engaging and interactive

experiences. This study explores the impact of gamification, specifically classroom game-based learning platforms, on senior secondary school students' engagement and knowledge retention in biology within Kwara State, Nigeria.

Biology, a core science subject, is essential for understanding life processes and tackling global challenges in areas such as health, agriculture, and environmental conservation. However, many students struggle with biology due to its complex and abstract concepts, which are often taught using traditional, lecture-based methods. These methods emphasize rote memorization rather than active engagement and understanding. Olarewaju (2020) noted that these challenges are prevalent in Nigerian secondary schools, particularly in regions like Kwara State, where limited resources aggravate the situation. Consequently, student disinterest and poor academic performance in biology have become pressing concerns that necessitate innovative approaches to teaching.

Classroom-based gamification offers a practical and accessible way to address these challenges. Unlike digital gamification, which relies heavily on technology, classroom-based gamification uses physical and interactive activities that can be easily implemented in resource-limited settings. For instance, games such as quizzes, classroom economy, quest-based learning, badge system, leaderboard challenges, escape room activities, spin the wheel, classroom battles, time trials, role-playing, and scavenger hunts allow students to engage with biology concepts in a hands-on and collaborative manner. Studies have shown that classroom games improve students' understanding of complex topics by making the learning process entertaining and relevant to their age group and day to day life. Miller and Rose (2015) argue that such activities create a playful environment that fosters active participation and deepens conceptual understanding.

One of the key benefits of gamification is its ability to enhance student engagement, which is a critical determinant of academic success. Fasuyi, Oladipo, and Udeani, (2022) defined engagement as the behavioral, emotional, and cognitive involvement of students in learning activities. Unfortunately, traditional teaching methods often fail to engage students effectively, leading to passive learning and low achievement. In contrast, gamification captures students' attention, evokes positive emotions, and encourages active participation in learning. Adesoji and Olusola (2019) found that activities such as biology scavenger hunts and role-playing significantly improved student engagement in Nigerian secondary schools, demonstrating the potential of gamification to transform classroom dynamics.

Another critical challenge in biology education is knowledge retention the ability to recall and apply learned information over time. Most a time, in traditional teaching approaches students struggle to retain concepts for examinations. Classroom-based gamification addresses this issue by promoting learner centered activities through repetitive and scenario-based tasks. These activities align with Vygotsky's (1978) social constructivist theory, which emphasizes the role of interaction and collaboration in knowledge construction. For example, classroom battles and team-based games encourage students to discuss ideas, solve problems, and reinforce their understanding through peer interactions. Huang and Soman (2013) demonstrated that gamified learning significantly improved knowledge retention among biology students, as the interactive nature of these activities made the learning experience more memorable.

In the Nigerian context, the application of gamification is particularly relevant due to the systemic challenges facing the education sector. Issues such as congested classrooms, inadequate teaching materials, and limited access to technology hinder effective teaching and learning. Ogunleye (2018) highlights these challenges, especially in rural and semi-urban areas like Kwara State. Classroom-based gamification offers a cost-effective and scalable solution, as it relies on simple tools and creative strategies that can be implemented with minimal resources.

Despite the global popularity of gamification in education, its application in Nigerian classrooms, particularly in biology, remains underexplored. Adedoyin (2019) conducted a study in Lagos State and found that incorporating gamified activities into science classrooms improved student engagement and knowledge retention. However, the study also emphasized the need for teacher training and curriculum adaptation to maximize the benefits of gamification. While these findings are promising, there is limited research specifically addressing the impact of classroom-based gamification on biology education in Kwara State.

This gap underscores the need for localized research to understand the effectiveness of gamification in improving student engagement and knowledge retention in biology. By focusing on classroom-based gamification, this study aims to provide practical insights that can be applied in resource-constrained settings. It seeks to determine how interactive, game-based learning platforms can transform the teaching and learning of biology for senior secondary school students in Kwara State.

The theoretical framework for this study is grounded in constructivist learning theory and self-determination theory. Constructivist learning theory, as proposed by Piaget (1952) and Vygotsky (1978), emphasizes active participation and collaboration in learning. Gamification aligns with this theory by creating environments where students actively engage with content and construct their knowledge through interaction. Self-determination theory (Deci & Ryan, 1985) further supports the motivational aspects of gamification, as it fulfills students' psychological needs for competence, autonomy, and relatedness, thereby enhancing their engagement and learning outcomes.

The significance of this study lies in its potential to improve biology education in Kwara State and contribute to the broader discourse on gamification in education. By providing empirical evidence on the effectiveness of classroom-based gamification, the study could inform curriculum design, teacher training, and educational policy. Furthermore, it highlights the relevance of gamification in resource-constrained settings, offering a model for other regions facing similar challenges.

Gamification has become an increasingly prominent strategy in education, offering a means to enhance learning experiences by incorporating game elements into teaching methodologies. It has been shown to improve student engagement, motivation and knowledge retention, particularly in subjects like science, where traditional teaching approaches often fail to capture students' interest. Biology, with its complex and abstract concepts, requires innovative instructional strategies to promote active learning and simplify understanding, making gamification a highly effective approach.

One of the primary benefits of gamification is its ability to increase student engagement. Engagement is a critical factor in academic success, yet conventional teaching methods

often leave students disinterested and passive. By introducing elements like competition, rewards, and challenges, gamification can make learning more interactive and stimulating. Yildirim and Şen (2021) found that incorporating gamified elements into science classrooms significantly enhanced students' emotional and cognitive involvement. Similarly, Adesoji and Olusola (2019) demonstrated that gamified activities such as quizzes and role-playing significantly improved the enthusiasm and participation of biology students in Nigerian secondary schools. These findings illustrate how gamification can shift the classroom dynamic, transforming students from passive listeners to active participants.

Another important aspect of gamification is its impact on knowledge retention. Retaining information over time is a common challenge for students, particularly in subjects like biology that involve extensive terminologies and abstract ideas. Gamification addresses this challenge by encouraging deep learning through interactive and repetitive tasks. Huang and Soman, (2013) showed that biology students who participated in gamified lessons exhibited better long-term retention compared to those taught through traditional methods. Collaborative games, such as team-based challenges and problem-solving tasks, were particularly effective, as they fostered peer learning and feedback. Similarly, Oladipo and Adebayo (2020) found that students who engaged in gamified biology lessons performed better on delayed post-tests, indicating that gamification strengthens the durability of knowledge.

The value of gamification is not confined to technologically advanced classrooms. In resource-constrained environments, teachers can be improvised for instructional materials. Adedoyin (2019) emphasized the potential of simple tools like flashcards, charts, and physical activities in introducing gamified learning into biology classrooms. These approaches are particularly significant in settings where access to digital resources is limited, ensuring that students in underprivileged areas can still benefit from engaging and interactive learning experiences. Ogunleye (2021) further highlighted that classroom-based gamification fosters inclusivity, allowing all students to participate regardless of their socioeconomic background.

Despite its advantages, the implementation of gamification in education is not without challenges. One significant obstacle is the lack of teacher readiness and training. Ali and Mohammed (2023) pointed out that many teachers are not equipped with the skills or confidence to effectively integrate gamified activities into their lessons. Addressing this issue requires targeted professional development programs to help educators understand and apply gamification strategies effectively. However, when implemented correctly, gamification has the potential to revolutionize education, making learning more engaging and meaningful for students.

In conclusion, studies have shown immense potential of gamification in improving engagement and knowledge retention in biology education. However, there is a pressing need for localized research to examine its specific impact in area like Offa, Kwara State, where educational challenges are unique. By investigating the effects of classroom-based gamification, this study aims to contribute valuable insights to the global discourse on innovative teaching practices and enhance biology education in resource-constrained settings.

Theoretical Framework

This study is grounded in constructivist learning theory and self-determination theory, which collectively explain the effectiveness of gamification in education. Constructivist learning theory, as proposed by Vygotsky (1978), emphasizes that learners construct knowledge actively through social interaction and engagement. Classroom-based gamification aligns with this theory by fostering collaborative and interactive learning environments that promote deeper understanding. Additionally, self-determination theory (Deci & Ryan, 1985) highlights the importance of intrinsic motivation in learning. Gamification satisfies students' psychological needs for competence, autonomy and relatedness through challenges, rewards, and teamwork, thereby increasing engagement and knowledge retention in biology education.

Statement of the problem

This study is justified by the critical need to address persistent challenges in biology education, particularly in resource-constrained settings like Kwara State, Nigeria. Biology, a core science subject, often suffers from low student engagement and poor knowledge retention due to traditional teaching methods that is teacher centered which emphasize rote memorization over active learning. These challenges hinder students' academic performance and limit their interest in pursuing careers in science-related fields. Gamification, an innovative teaching strategy, has been shown to improve engagement and retention by transforming learning into an interactive and enjoyable experience. However, most studies on gamification in education focus on digital platforms and are conducted in developed countries, leaving a gap in localized research on low-cost, classroom-based gamification in Nigeria. Addressing this gap is crucial, as classroom-based games are more accessible and practical for schools in Kwara State, where digital resources are limited.

By investigating the impact of classroom game-based learning platforms on student engagement and knowledge retention in biology, this study provides evidence-based insights that can inform curriculum development, teacher training and educational policies. Ultimately, it aims to enhance the quality of biology education, improve learning outcomes and contribute to the global discourse on effective teaching strategies in science education.

Objectives of the Study

1. To examine the impact of classroom-based game-based learning platforms on student engagement in biology among senior secondary school students in Kwara State.
2. To assess the effect of classroom-based gamification on knowledge retention in biology among senior secondary school students in Kwara State.

Research Questions

1. How does the use of classroom game-based learning platforms influence student engagement in biology among senior secondary school students in Kwara State?
2. What is the effect of classroom-based gamification on knowledge retention in biology among senior secondary school students in Kwara State?

Research Hypothesis

H_{o1}: There is no significant difference between classroom game-based learning platforms and student's engagement in biology among senior secondary school students in Kwara State

H_{o2}: There is no significant difference effect of Classroom-based gamification on knowledge retention in biology among senior secondary school students in Kwara State.

Methodology

The study employed a quasi-experimental research design to investigate the effect of game-based learning platforms on senior secondary students' engagement and knowledge retention in Biology in kwara State, Nigeria. The design involved two groups, an experimental group, which was exposed to gamified learning strategies, and a control group, which received traditional lecture-based teaching. The study was conducted in two public senior secondary schools in Offa, Kwara State. Senior secondary II (SS II) students of 50 and 53 students respectively in intact classes were involved in the study to ensure the natural classroom setting was preserved.

Experimental Group	**Control Group**
(School A)	(School B)
|	|
Pre-Test	Pre-Test
|	|
Gamified Teaching	Traditional Teaching
|	|
Post-Test	Post-Test
|	|
Compare Engagement and Knowledge Retention Outcomes	

The population for the study comprised senior secondary school II (SS II) biology students in Offa, Kwara State. Two schools were purposively selected based on their accessibility and willingness to participate in the study. One intact class from each school was randomly assigned to the experimental or control group. Fifty 50 and 53 Senior secondary II (SS II) students respectively were involved in the study to ensure the natural classroom setting was preserved.

The instrument for data collection was a researcher-designed **Biology Achievement Test (BAT)** and a **Student Engagement Questionnaire (SEQ)**. The BAT consisted of 30

multiple-choice questions covering the topics taught during the study, validated by subject experts to ascertain the content and face validity. The SEQ, adapted from Fredricks, Blumenfeld, & Paris (2004), measured behavioral, emotional, and cognitive engagement through a 4-point Likert scale. Both instruments were subjected to pilot testing to determine the reliability. Cronbach's alpha values of 0.85 and 0.78 for the BAT and the SEQ respectively, indicating high reliability.

Data collection lasted for four weeks. In the experimental group, the teacher used gamified strategies such as biology quizzes, classroom economy, quest-based learning, badge system, leaderboard challenges, escape room activities, classroom battles, time trials, and scavenger hunts to teach the assigned topics. The control group received conventional lecture-based instruction on the same topics. Both groups were taught by their regular biology teachers, who were trained beforehand to ensure uniformity in the teaching.

Pre-tests were conducted to both groups to assess their previous knowledge and engagement levels before the intervention. After the treatment of about three weeks post-tests were administered after using the BAT and SEQ to measure changes in knowledge retention and engagement. Observations were made in the experimental group to assess students' responses to gamified activities.

The data analyzed using descriptive and inferential statistics. Mean and standard deviation were used to answer research questions and Analysis of Co-variance (ANCOVA) were used to test the two hypotheses at 0.05 level of significance.

Ethical Considerations

Ethical considerations were strictly adhered to throughout the study. Permission was sought from the Kwara State Ministry of Education and Human Capital Development and the principals of the selected schools. Informed consent was secured from the students and their parents or guardians, to ensure voluntary participation. Anonymity and confidentiality were upheld by coding participants' data and avoiding the use of identifiable information. Students in the control group were assured that they would benefit from the gamification strategies after the study to mitigate any perceived disadvantage.

Results

The findings of this study were presented in the following tables:

Answering Research questions

Research Question 1: How does the use of classroom game-based learning platforms influence student engagement in biology among senior secondary school students in Kwara State?

Table 1: Use of Classroom Game-based Learning Platform and Students' Engagement

Group	Number of Respondents	Mean Engagement Score	Standard Deviation	Minimum Score	Maximum Score
Experimental	50	7.8	1.5	5	10
Control	53	5.1	1.2	3	8

Table 1 indicated that the experimental group exhibited a higher mean engagement score (7.8) compared with the control group (5.1), this implied that classroom-based gamification enhances students' engagement.

Research Question 2: What is the effect of classroom-based gamification on knowledge retention in biology among senior secondary school students in Kwara State?

Table 2: Use of Classroom Game-Based Learning Platform and Students' Knowledge Retention

Group	Number of Respondents	Mean Knowledge Score	Standard Deviation	Minimum Score	Maximum Score
Experimental	50	78.2	8.4	60	95
Control	53	58.3	7.6	45	75

Table 2 revealed that the experimental group achieved a higher mean knowledge retention score (78.2) compared with the control group (58.3), indicating that classroom-based gamification positively improves knowledge retention among biology students.

Research Hypotheses

H_{01}: There is no significant difference between classroom game-based learning platforms and student's engagement in biology among senior secondary school students in Kwara State.

Table 3: ANCOVA Showing the Effect of Classroom Game-based Learning Platforms on Student Engagement

Source	Sum of Squares	df	Mean Square	F	p-value
Teaching Method	210.35	1	210.35	98.76	<0.001
Pre-Engagement Score (Covariate)	15.42	1	15.42	7.24	0.008
Error	132.67	99	1.34		
Total	**358.44**	**101**			

Table 3 showed a significant effect of the teaching method on student engagement after controlling for pre-engagement scores. The experimental group (gamification) showed higher engagement levels of (F, 98.76) greater than P-value (0.001) when compared to the control group, thus, the null hypothesis was rejected.

This suggests that the use of game-based learning platforms significantly affect student engagement in biology, supporting the rejection of the null hypothesis. The control group,

which did not use gamification strategies, displayed lower engagement scores compared to the experimental group, where gamified learning was adopted.

H_{o2}: There is no significant difference effect of Classroom-based gamification on knowledge retention in biology among senior secondary school students in Kwara State.

Table 4: ANCOVA Showing the Effect of Classroom Game-based Learning Platforms on Knowledge Retention

Source	Sum of Squares	df	Mean Square	F	p-value
Teaching Method	18,250.47	1	18,250.47	162.58	0.001
Pre-Knowledge Score (Covariate)	1,200.56	1	1,200.56	10.69	0.001
Error	11,102.34	99	112.15		
Total	**30,553.37**	**101**			

Table 4 revealed a significant effect of the teaching method on knowledge retention after controlling for pre-test knowledge scores. Students in the experimental group demonstrated higher knowledge retention with (F, 162.58) greater than P-value of (0.001) compared to those in the control group, thus the null hypothesis was rejected.

Discussion

The findings of this study revealed that classroom game-based learning platform significantly enhances student engagement and knowledge retention in biology among senior secondary school students in Kwara State. The ANOVA results showed statistically significant differences in engagement and retention scores between the experimental group and the control group. This implies that there is different between performance of students exposed to gamification in engagement and knowledge retention than student taught with conventional method of teaching. This underscores the potential of classroom game-based learning platform as a transformative strategy in improving science education, particularly in a resource-limited area like Kwara State.

This study is in agreement with the findings of Obafemi and Adekunle (2021), who reported that gamification strategies create an interactive and enjoyable learning atmosphere, particularly in Nigerian classrooms with limited educational resources. Similarly, Hamari, Koivisto nd Sarsa (2014) conducted a meta-analysis and revealed gamification's effectiveness in boosting behavioral, emotional, and cognitive engagement across diverse educational settings.

Knowledge retention was also significantly higher among students exposed to gamification. This finding corroborates the study by Ibrahim and Olawale (2020), who demonstrated that Nigerian secondary school students taught with game-based techniques retained biology concepts more effectively than those taught using traditional methods. Furthermore, Su and Cheng (2015) showed that game-based learning improves long-term

memory by actively involving learners in problem-solving and reinforcing concepts through repetition in a fun and engaging manner.

The results of this study was in line with the study of Akinpelu et al. (2022), who found that gamification fosters collaborative learning and peer interactions, which enhance understanding and retention of complex scientific concepts. In the international context, Kapp (2012) emphasized that gamification leverages intrinsic motivators like challenge and extrinsic rewards to create a meaningful learning experience, leading to better knowledge assimilation. Besides, Charsky (2010) revealed that the immediate feedback inherent in gamification reinforces learning and helps students identify and correct misconceptions early, further improving retention.

The findings of this study also provide local relevance, addressing the challenges of low student engagement and poor academic outcomes in Kwara State. Ajayi and Bamigboye (2019) pointed out that reliance on traditional lecture-based teaching methods in many Nigerian schools often fails to capture students' interest or meet the demands of 21st-century learning. By adopting classroom-based gamification, biology teachers in Kwara State can overcome these limitations and create a more dynamic and effective learning environment. The results of this study confirmed that gamification is a powerful pedagogical tool that promotes engagement and knowledge retention, supported by both local and international research. Its adoption in classrooms has the potential to transform biology education, particularly in underperforming schools, by making learning more interactive, enjoyable, and impactful.

Conclusion

The study confirmed the transformative potential of classroom game-based learning platform in biology education, particularly in areas facing educational challenges. By fostering a more engaging and interactive learning atmosphere, gamification not only enhances knowledge retention but also addresses the pressing need for innovative teaching strategies. The positive outcomes observed in this research advocate for the broader adoption of gamified approaches in educational settings, ultimately contributing to improved student performance and motivation in biology and beyond.

Recommendations

The findings of this study recommended that schools should incorporate classroom game-based learning strategies into the biology curriculum to enhance student engagement and improve academic performance.

School management, ministry of education should provide a platform for training and retrained of teachers on the use of gamification techniques to effectively implement these strategies in the classroom.

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