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Effect of Gamification on Academic Achievement in Population Ecology among Senior Secondary School Biology Students in Akwa Ibom State

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ABSTRACT

This study investigated the effect of gamification on Biology students' academic achievement in population ecology in senior secondary schools in Akwa Ibom State. Two null hypotheses guided the research, which employed a quasi-experimental design. The population consisted of 8,364 SS2 Biology students, with a sample size of 138 students selected for the study. Data collection was facilitated using the Biology Achievement Test, which had a reliability coefficient of 0.82 determined through Kuder Richardson's formula 21. Data analysis was conducted using mean scores and Analysis of Covariance. The results revealed that students taught using gamification significantly outperformed those taught using the lecture method in academic achievement. Additionally, gender did not significantly influence students' academic performance. Based on these findings, it is recommended that Biology teachers adopt gamification as an effective teaching strategy for population ecology to enhance students' learning outcomes.

Keywords: Gamification, Academic Achievement, Biology, Teaching Strategies

1. Introduction

Science and technology have long been regarded as key drivers of economic development in industrialized nations, playing a crucial role in humanity's quest to understand and manipulate the environment for a more prosperous future. Miller and Levine (2017) highlight that national development primarily stems from advancements in science and technology. In recognition of this, many developing countries, including Nigeria, are intensifying efforts to enhance science education. Nigeria's education policy emphasizes this by mandating a 60:40 admission ratio of science to arts-related courses in tertiary institutions to cultivate a workforce equipped to drive economic transformation, particularly in sectors like the oil industry (Federal Republic of Nigeria, 2013). Moreover, Nigeria's 9-3-4 education system is structured to promote self-reliance and sustainable national development, underscoring the critical role of science and technology.

Biology, as one of the foundational sciences, is pivotal for technological advancements. It provides insights into the natural world and underpins careers in medicine, pharmacy, agriculture, and engineering (Chew, 2014). The Biology curriculum in Nigerian secondary schools is designed to impart laboratory skills, scientific knowledge, and practical applications in everyday life, addressing issues in health, agriculture, and environmental management (Ado & Udoh, 2018). The subject's importance has been further emphasized by researchers who link it to better health understanding, career development, and problem-solving skills in society (Cakir, 2017; Institute of Biology, 2013).

Despite its significance, the teaching and learning of Biology face challenges, particularly regarding abstract and complex topics like population ecology. Reports, including the West African Examination Council (WAEC) Chief Examiner's report (2019), indicate poor student performance in Biology due to factors such as inadequate teaching strategies, lack of laboratory resources, and deficiencies in curriculum delivery (Okorie, 2018; Omatade, 2016). Traditional lecture-based teaching methods, which emphasize rote memorization and teacher-centered learning, fail to engage students effectively or foster critical thinking (Etiubon & Udoh, 2017).

Population ecology, a branch of Biology focused on the dynamics of species populations and their environmental interactions, exemplifies a topic that demands innovative teaching approaches. Given its significance in understanding ecosystems, energy transformation, and species interactions (Michael, 2019; Orrock, 2018), adopting strategies like gamification—an interactive method that incorporates game elements into learning—could enhance student engagement and achievement. Gamification has been shown to motivate learners, foster collaboration, and promote active participation, yielding better learning outcomes (Hamari, 2019; Haman & Brown, 2022).

This study aims to explore the effects of gamification compared to traditional lecture methods on secondary school students' academic achievement in population ecology in Akwa Ibom State, Nigeria. Specifically, it seeks to:

i) Determine the differences in the mean achievement scores of students taught population ecology using gamification and those taught using the lecture method.

ii) Ascertain the differences in the mean achievement scores of male and female Biology students taught population ecology using gamification.

To address these objectives, the study will answer the following research questions:

i) What are the differences in the mean achievement scores of students taught population ecology using gamification compared to those taught using the lecture method?

ii) What are the differences in the mean achievement scores of male and female Biology students taught population ecology using gamification?

2. Research Method

The study adopted a non-randomized pretest-posttest control group quasi-experimental design to investigate the effects of gamification on students' achievement in Biology. The population comprised all 8,364 Senior Secondary Two (SS2) Biology students enrolled during the 2023/2024 academic session across the three local education zones in Akwa Ibom State. A sample of 138 SS2 Biology students was selected using a purposive sampling technique, with participants drawn from two intact classes in two schools within the study area. Students in the experimental group were taught using the gamification strategy, while the control group received instruction through the traditional lecture method.

Data collection was facilitated through two instruments: the Biology Interest Scale in Population Ecology (BISIPE) and the Biology Achievement Test in Population Ecology (BATIPE). Both instruments were validated by three lecturers from the Department of Science Education at Michael Okpara University of Agriculture, Umudike. The reliability of the instruments was established with a Cronbach's Alpha coefficient of 0.90 for BISIPE and a Kuder-Richardson Formula 21 coefficient of 0.82 for BATIPE.

The data were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at a 0.05 level of significance. The ANCOVA analysis ensured that any pre-existing differences among the groups were statistically controlled, providing a robust assessment of the comparative effects of the gamification strategy and the lecture method on students' academic performance and interest in Biology.

3. Results

Research Question One

What are the differences in the mean achievement scores of students taught population ecology using gamification and those taught using the lecture method?

Table 1: Mean and Standard Deviation of pre-test and Post test Academic scores of Students taught Population ecology using gamification and lecture method

	Pre-test			Post-test		
Instructional Strategy	N	$\bar{X}$	SD	$\bar{X}$	SD	Mean Difference
Gamification	69	22.79	5.67	67.60	6.24	44.81
Lecture method	69	22.23	5.64	52.74	4.78	30.51

Results in Table 1 shows that the mean pre-test scores of students' taught population ecology as a concept using gamification and lecture method are 22.79 and 22.23 respectively with standard deviation scores as 5.67 and 5.64 respectively. Their respective mean post-test scores are 67.60 and 52.74 with standard deviation scores as 6.24, and 4.78 respectively.

The table also shows that the mean difference of students scores taught using gamification and lecture method are 44.81 and 30.51 respectively. It can be inferred from the result in table 1 that biology students taught with gamification performed better that those taught using the lecture method.

Research Question Two

What difference exists in the mean achievement scores of male and female biology students taught population ecology using gamification strategy?

Table 2: Mean and Standard Deviation of male and female biology students pre-test and Post test scores taught Population ecology using gamification

		Pre-test			Post-test		
Instructional Strategy	Gender	N	$\bar{X}$	SD	$\bar{X}$	SD	Mean Difference
Gamification	Male	36	22.09	5.21	68.19	6.86	46.10
	Female	33	23.46	6.24	67.46	6.11	44.00

As shown on Table 2, the mean difference achievement scores of male students taught population ecology using gamification was 46.10 and that of their female counterpart, 44.00. It can be inferred from the table that male students taught population ecology using gamification did not significantly achieve higher scores compared to their female counterparts. This indicates that gamification proved to be more effective in improving the mean achievement scores of all students in population ecology.

Test of Hypotheses

The null hypotheses were analysed using Analysis of Covariance (ANCOVA) at .05 alpha level using a pre-test as a covariate. Hypotheses were rejected when the f-value was less than p-value of 0.05 at the alpha level of significance and were not rejected when the f-value was greater than the p-value of 0.05 at the alpha level of significance.

Hypothesis One

H_o: There is no significant difference in the mean achievement scores of biology students taught population ecology using gamification and those taught using the lecture method. The results of the analysis is presented in Table 3

Table 3: Analysis of covariance (ANCOVA) of students' post-test scores classified by instructional strategies (gamification and lecture method) with pre-test scores as covariate

Source of variation	SS	DF	MS	F-cal	P-value
Corrected model	22547.01	12	1878.92	146.27	.00
Covariate (pre-test)	3561.72	1	3561.72	277.28	.08
Main effect (instructional strategies)	521.90	2	260.95	20.32	.00
Error	6872.23	227	12.85		
Corrected total	26406.56	239			

* Significant at $p < 0.5$

Results in Table 3 shows that the analysis of covariate (pre-test scores) of the two groups of students taught population ecology using gamificatiion and lecture method. The table also shows that the f-value (20.32) having a p-value (.00) of the main effects of strategies is less than the significant level (0.05), therefore, the null hypothesis two is rejected. The rejection of the null hypotheses implies that there exist a significant difference in the mean achievement scores of biology students taught population ecology using gamification and those taught using lecture method.

Hypothesis Two

H_o: There is no significant difference in the mean achievement scores of male and female biology students taught population ecology using gamification. The results of the analysis is presented in Table 5

Table 4: Analysis of covariance of academic achievement of students taught population ecology using gamification based on gender

Source of variation	SS	DF	MS	F-value	P-value
Corrected model	19534.34	12	1627.86	53.77	.00
Covariate (pre-test)	270.99	1	63.59	8.95	.13
Main effect (instructional strategies)	9571.86	2	4785.93	158.09	.06
Gender	549.63	1	549.63	18.16	.08

Error	26406.56	27	30.27
Corrected total	26406.56	239	

* Significant at $p < 0.05$

As shown in Table 4, the f-value (0.08) is greater than the alpha level (0.05). Therefore, the null hypothesis two is not rejected. This implies that there exists no significant difference between the academic achievement of male and female biology students taught population ecology using gamification.

4. Discussion of Findings

The analysis of the study's findings provides substantial evidence supporting the integration of gamification into Biology education, especially in teaching complex topics like population ecology. The superior academic achievement exhibited by students taught using gamification as opposed to the lecture method reflects the effectiveness of interactive and immersive learning approaches. Gamification transforms traditional instruction into a dynamic process by incorporating elements such as simulations, challenges, instant feedback, and rewards, fostering active engagement and critical thinking. This aligns with Güler and Güler's (2015) findings, which emphasize the dual benefits of gamification in increasing students' academic performance and intrinsic motivation. Such outcomes suggest that gamification not only makes learning enjoyable but also improves students' ability to grasp and apply scientific concepts more effectively than passive methods like lectures.

The heightened academic success seen in gamification-supported learning environments can also be attributed to its alignment with modern pedagogical theories such as constructivism and experiential learning. By allowing students to interact with content actively, gamification promotes deeper cognitive processing and knowledge retention. It shifts the role of students from passive recipients to active participants, engaging them in problem-solving scenarios that mimic real-world applications. This hands-on approach can be particularly beneficial in teaching population ecology, a subject requiring comprehension of dynamic systems and critical analysis of environmental data.

Furthermore, the absence of a significant gender difference in academic achievement among students exposed to gamification is a key finding that challenges persistent stereotypes in science education. Cigdem's (2018) assertion that gender does not significantly influence academic success when active learning strategies are used reinforces this study's conclusion. By creating a learning environment that is equally accessible and engaging to all students, gamification neutralizes traditional barriers that may have hindered one gender more than the other. This outcome is critical in promoting gender equity in science, technology, engineering, and mathematics (STEM) education. The finding suggests that gamification has the potential to be a great equalizer, ensuring that instructional strategies are inclusive and benefit all learners regardless of gender.

Moreover, this result provides practical implications for educators and policymakers. Educators can confidently adopt gamification, knowing that it does not favor one gender over another, while policymakers and curriculum developers can use this evidence to advocate for broader implementation of gamified learning environments in schools. Incorporating gamification into classroom instruction can also complement efforts to address larger systemic issues, such as the gender gap in STEM professions, by fostering early interest and competence among students of all genders.

Additionally, the findings contribute to the growing body of literature advocating for the use of active learning strategies. In contrast to the rigidity and monotony often associated with the lecture method, gamification introduces flexibility and creativity into teaching. Students are given the autonomy to explore, experiment, and learn at their own pace, which enhances their academic achievement. By emphasizing teamwork, competition, and problem-solving, gamified strategies also cultivate skills that extend beyond academic performance, including collaboration, communication, and adaptability—qualities essential for success in the 21st century.

Finally, the study underscores the importance of adopting innovative teaching methods to address contemporary educational challenges. Traditional lecture methods, while foundational, are increasingly insufficient to meet the needs of today's learners, who are more accustomed to interactive, technology-driven experiences. Gamification bridges this gap by leveraging digital tools and game mechanics to make learning both relevant and impactful. Its success in enhancing academic achievement in population ecology suggests its applicability across other complex or traditionally challenging subjects in Biology and beyond.

5. Conclusion

This study investigated the effects of gamification and the lecture method on the academic achievement of senior secondary school Biology students in Akwa Ibom State. The findings showed that gamification significantly enhanced academic achievement compared to the lecture method, demonstrating its effectiveness as a teaching strategy. Additionally, the study revealed that gender was not a significant factor in determining students' academic performance when gamification was employed. These results emphasize the inclusivity and efficacy of gamification in teaching Biology and suggest it can be used to challenge gender stereotypes in educational performance.

Based on the study's findings, several recommendations are proposed. First, Biology teachers should adopt gamification as a teaching strategy since it has proven to enhance academic achievement without being influenced by gender differences. Second, the government should organize seminars and workshops to train Biology teachers on the effective use of gamification in classroom instruction. Third, curriculum developers should integrate gamified learning modules into the Biology curriculum to foster active learning and improved student engagement. Finally, further research should be conducted

to investigate the long-term impact of gamification on other educational outcomes, such as critical thinking and problem-solving skills, across various subjects and student demographics.

Despite the study's strengths, such as its innovative design and relevance to modern educational practices, the study had some limitations. The research was conducted in a specific region, which may limit the generalizability of the results. Additionally, the study did not account for long-term effects or potential confounding variables such as teacher competence or socio-economic factors. Future research could address these limitations by broadening the sample, exploring long-term impacts, and controlling for external variables. Nonetheless, the study offers valuable insights into the potential of gamification to improve academic outcomes in Biology education.

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