MATHEMATICAL CONSTRUCTION SKILLS AS A PREDICTOR OF BIOLOGY ACHIEVEMENT AMONG SECONDARY SCHOOL STUDENTS IN BAYELSA STATE

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Abstract
This study investigated the extent to which students' proficiency in mathematical construction skills predicts their achievement in biology among secondary school students in Bayelsa State, as well as the influence of gender on this predictive relationship. A correlational research design was adopted to explore the nature of the relationship between the variables. The population comprised all 4567 senior secondary school biology students in Bayelsa State, from which a sample of 200 students was selected using a stratified random sampling technique to ensure adequate gender representation. Data were collected using two standardized instruments: the Mathematical Construction Skills Test (MCST) and the Biology Achievement Test (BAT). The instruments were validated by experts in Measurement and Evaluation, and their reliability coefficients, obtained through Cronbach's Alpha, were 0.82 and 0.86 respectively, indicating strong internal consistency. Data were analyzed using simple linear regression at a 0.05 level of significance. Findings revealed a significant positive predictive relationship between students' proficiency in mathematical construction skills and their achievement in biology ($\beta = 0.590$, $p < 0.05$), while gender had no significant influence on this relationship ($p > 0.05$). The study concluded that mathematical construction skills are crucial in enhancing students' academic performance in biology, regardless of gender. It was recommended that teachers integrate mathematical construction activities into biology instruction and that gender-inclusive pedagogical strategies be adopted to ensure equitable learning outcomes for all students.

Keywords: *Mathematical Construction Skills, Biology Academic Achievement, Secondary School Students.*

Introduction

From the earliest stages of human civilization, the study of mathematics and science has been central to intellectual development and technological progress. Mathematics, as a discipline, serves as the language of science, providing the essential tools for logical reasoning, measurement, and problem-solving across diverse fields (Adedayo & Yusuf, 2020). Biology, as one of the core sciences, relies significantly on mathematical principles for accurate data analysis, graphical representation, and quantitative reasoning (Ukwuani & Eze, 2021). Thus, the interconnection

between mathematics and biology is undeniable, as mathematical skills provide the foundation for understanding biological processes such as population dynamics, genetics, biochemical reactions, and ecological relationships (Okonkwo, 2019). In the modern educational landscape, developing mathematical construction skills—such as measurement accuracy, graphical interpretation, and spatial visualization—is increasingly recognized as a crucial factor influencing students' achievement in biology.

Mathematical construction skills refer to the ability to apply mathematical concepts and tools in representing and solving real-life problems through drawings, graphs, models, and quantitative reasoning (Nwosu & Dike, 2020). These skills enable students to interpret biological data effectively, construct and analyze graphs, and make informed predictions about experimental outcomes. In secondary schools, topics such as genetics, photosynthesis, enzyme activity, and ecology demand mathematical precision for accurate understanding (Eze & Ogbonna, 2022). However, research evidence in Nigeria and other developing nations suggests that many students struggle with biology because they lack the mathematical competencies required to engage with data-driven scientific concepts (Ajayi, 2021). Consequently, the weak foundation in mathematical construction often translates into poor academic achievement in biology.

Academic achievement in biology is influenced by multiple factors, including students' cognitive abilities, prior knowledge, instructional strategies, and the integration of interdisciplinary skills (Ogunleye & Ojo, 2021). Among these, mathematical construction skills play a predictive role, as students who possess strong mathematical reasoning tend to perform better in science subjects that demand numerical and graphical interpretation (Adewumi & Bello, 2020). Studies have shown that proficiency in mathematical construction contributes to better comprehension of experimental data and enhances performance in biology examinations (Olaniyi, 2022). This relationship

highlights the need to examine the extent to which mathematical construction skills predict students' academic achievement in biology, especially within the context of Nigerian secondary education, where the integration of mathematics into science instruction is often weak.

Furthermore, gender remains an important factor influencing students' academic performance in mathematics and science-related subjects. While some studies have shown that male students outperform females in mathematical tasks due to differences in spatial reasoning and confidence (Asuru & Okafor, 2020), others argue that such disparities are context-dependent and influenced by teaching methods, socio-cultural expectations, and exposure to practical learning experiences (Nnamdi & Effiong, 2022). Understanding whether gender moderates the relationship between mathematical construction skills and biology achievement can provide valuable insights into equitable instructional approaches.

In Nigeria, the Federal Republic of Nigeria (FRN, 2014) emphasized the importance of mathematics as a core subject at all levels of education, asserting that its knowledge is essential for scientific and technological advancement. Despite this, persistent reports from the West African Examinations Council (WAEC) indicate a recurring pattern of low achievement in biology, with examiners attributing part of the problem to poor mathematical interpretation of data and inability to construct accurate biological diagrams and graphs (WAEC Chief Examiners' Report, 2023). The situation calls for empirical studies that explore the predictive role of mathematical construction skills on students' academic achievement in biology, particularly in Bayelsa State, where science education outcomes continue to raise concern.

Therefore, this study investigates mathematical construction skills as a predictor of biology academic achievement among secondary school students in Bayelsa State, while also examining the influence of gender on this predictive relationship. The findings are expected to provide

empirical evidence that will guide teachers, curriculum planners, and policymakers in designing integrative instructional strategies that strengthen students' mathematical foundations for better achievement in biology and related sciences.

Purpose of the Study

The main purpose of this study was to examine the extent to which mathematical construction skills predict biology achievement among secondary school students in Bayelsa State. Specifically, the study sought to:

1. Determine the extent to which students' proficiency in mathematical construction skills predicts their achievement in biology among secondary school students in Bayelsa State.
2. Determine the extent to which gender influences the predictive relationship between students' mathematical construction skills and their achievement in biology among secondary school students in Bayelsa State.

Research Questions

The following research questions were raised to guide the study:

1. What is the extent to which students' proficiency in mathematical construction skills predicts their achievement in biology among secondary school students in Bayelsa State?
2. What is the extent to which gender influences the predictive relationship between students' mathematical construction skills and their achievement in biology among secondary school students in Bayelsa State?

Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance:

H_{01}: There is no significant predictive relationship between students' proficiency in mathematical construction skills and their achievement in biology among secondary school students in Bayelsa State.

H_{02}: Gender does not significantly influence the predictive relationship between students' mathematical construction skills and their achievement in biology among secondary school students in Bayelsa State.

Research Methods

This study adopted a correlational research design, deemed appropriate for determining the extent to which one variable predicts another within a defined population. According to Charles-Owaba (2019), correlational research is useful for systematically exploring statistical relationships between variables without manipulating them. In this study, the focus was on examining how students' mathematical construction skills predict their academic achievement in biology among secondary school students in Bayelsa State. The independent variable was mathematical construction skills, while the dependent variable was biology academic achievement, with gender considered as a moderating variable.

The population of the study comprised all 4567 senior secondary school students offering biology in public secondary schools across Bayelsa State during the 2024/2025 academic session. A total sample of 200 students was drawn using a multistage sampling technique. In the first stage, the state was stratified into the three senatorial districts: Bayelsa Central, Bayelsa East, and Bayelsa West. In the second stage, two schools were randomly selected from each district. Finally, using proportionate stratified random sampling, students were selected from each school to ensure representation based on gender and class level (SS I and SS II).

Data were collected using two researcher-developed instruments titled: Mathematical Construction Skills Test (MCST) and Biology Achievement Test (BAT). The MCST consisted of structured items designed to assess students' competencies in geometric drawing, measurement accuracy, graph plotting, and data interpretation, while the BAT measured students' achievement in key areas of the biology curriculum such as genetics, ecology, and human physiology. Both instruments were

structured in a multiple-choice format. The instruments were validated by three experts—two from the Department of Science Education and one from the Department of Measurement and Evaluation at the Federal University Otuoke—who reviewed the items for content relevance, clarity, and alignment with the study objectives.

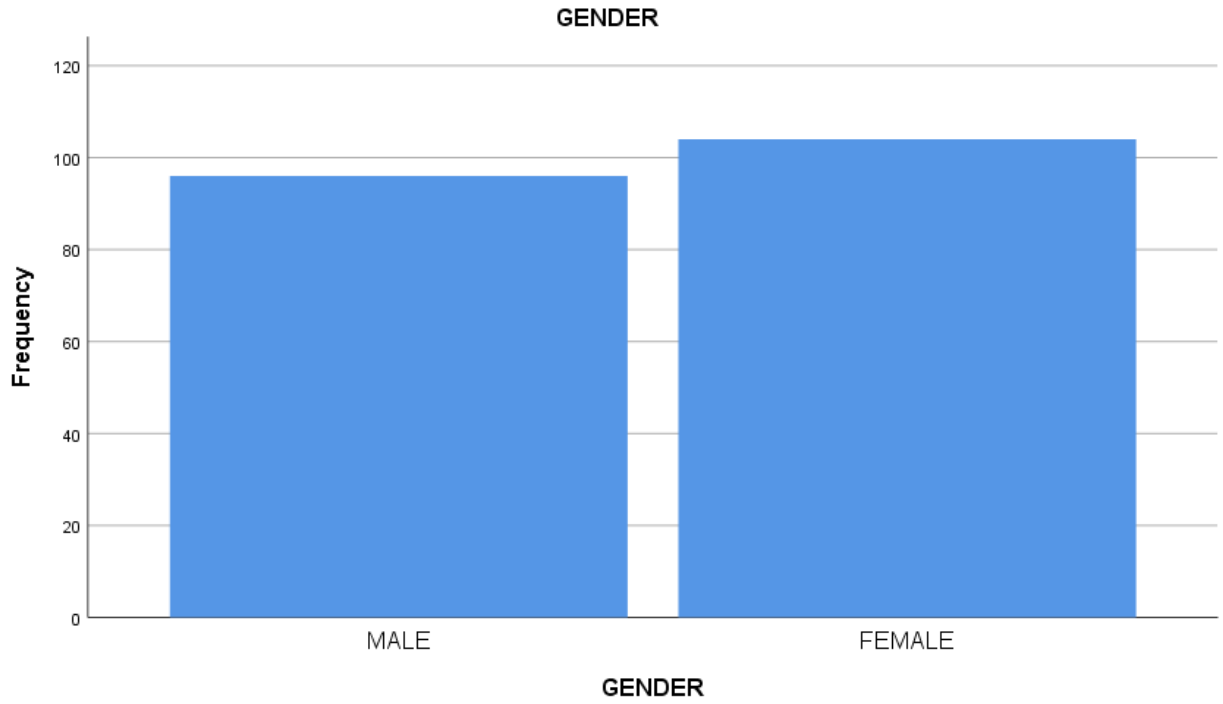
A pilot test was conducted with 30 biology students from two schools in Delta State (outside the main study area) to determine the instruments' reliability. Using the Cronbach's Alpha method, reliability coefficients of 0.84 for the MCST and 0.86 for the BAT were obtained, indicating high internal consistency. The main data collection was carried out by the researcher with the help of trained research assistants. Before administration, clear instructions were given to ensure that all respondents understood the procedures. Completed instruments were collected immediately after administration to ensure a high response rate and minimize loss of data.

For data analysis, inferential statistics were used to test the study hypotheses at a 0.05 level of significance. Specifically, Simple Linear Regression Analysis was employed to determine the extent to which students' mathematical construction skills predicted their biology academic achievement. In addition, Multiple Regression Analysis was used to assess the moderating effect of gender on the predictive relationship between mathematical construction skills and biology achievement.

Results

Demographic Analysis

	Frequency	Percent	Valid Percent	Cumulative Percent
MALE	96	48.0	48.0	48.0
FEMALE	104	52.0	52.0	100.0
Total	200	100.0	100.0	



The data presented in Table 4.1.1 above shows that 96 (48.0%) of the respondents were male, while 104 (52.0%) were female. This implies that female students constituted a slightly higher proportion of the study sample compared to their male counterparts, indicating a fairly balanced gender representation among the respondents used for the study.

Research Question 1

What is the extent to which students' proficiency in mathematical construction skills predicts their achievement in biology among secondary school students in Bayelsa State?

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.590[a]	.348	.345	7.28500

The result presented in Table 2 shows that students' proficiency in mathematical construction skills has a moderate positive predictive relationship with their achievement in biology, as indicated by the correlation coefficient (R) of 0.590. The R Square value of 0.348 reveals that approximately 34.8% of the variation in students' biology achievement can be explained by their proficiency in mathematical construction skills, while the remaining 65.2% may be attributed to other factors not included in the model. This finding implies that students who demonstrate higher proficiency in mathematical construction skills tend to achieve better results in biology among secondary school students in Bayelsa State.

Table 3: ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	5611.965	1	5611.965	105.744	.000[b]
	Residual	10508.091	198	53.071		
	Total	16120.056	199			

Research Question 2

What is the extent to which gender influences the predictive relationship between students' mathematical construction skills and their achievement in biology among secondary school students in Bayelsa State?

Table 3: **Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.590[a]	.348	.342	7.30200

The result presented in Table 3 indicates that gender has little influence on the predictive relationship between students' mathematical construction skills and their achievement in biology. The correlation coefficient (R) of 0.590 shows a moderate positive relationship, while the R Square

value of 0.348 implies that about 34.8% of the variation in students' biology achievement can be explained by their mathematical construction skills when gender is considered. The slight decrease in the adjusted R Square value to 0.342 suggests that gender contributes minimally to the predictive strength of the model. This finding implies that, although both male and female students benefit from proficiency in mathematical construction skills, gender does not significantly alter the relationship between these skills and achievement in biology among secondary school students in Bayelsa State.

Hypotheses

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	8.841	3.640		2.429	.016
	MATHS CONSTRUCTION SKILLS TEST	.550	.054	.590	10.257	.000
	GENDER	.290	1.034	.016	.281	.779

a. Dependent Variable: BIOLOGY ACHIEVEMENT TEST

H_{01}: There is no significant predictive relationship between students' proficiency in mathematical construction skills and their achievement in biology among secondary school students in Bayelsa State.

The result in Table 4 shows that students' proficiency in mathematical construction skills significantly predicts their achievement in biology among secondary school students in Bayelsa State. The unstandardized coefficient (B = 0.550) with a standard error of 0.054 indicates that for every unit increase in mathematical construction skills, students' biology achievement increases by 0.55 units. The standardized beta coefficient ($\beta = 0.590$) further confirms a moderate positive predictive relationship between the two variables. The t-value of 10.257 with a corresponding significance value of 0.000 ($p < 0.05$) leads to the rejection of the null hypothesis (H_{01}). This

implies that mathematical construction skills significantly predict students' achievement in biology, suggesting that proficiency in mathematical reasoning and spatial construction contributes meaningfully to students' understanding and performance in biology.

H_{02}: Gender does not significantly influence the predictive relationship between students' mathematical construction skills and their achievement in biology among secondary school students in Bayelsa State.

The result also shows that gender does not significantly influence the predictive relationship between students' mathematical construction skills and their biology achievement. The unstandardized coefficient (B = 0.290) with a standard error of 1.034 indicates a negligible effect of gender on the model. The standardized beta value ($\beta = 0.016$) and a t-value of 0.281, with a corresponding p-value of 0.779 ($p > 0.05$), confirm that the influence of gender is not statistically significant. Therefore, the null hypothesis (H_{02}) is accepted. This finding implies that the predictive strength of mathematical construction skills on biology achievement is consistent across both male and female students, suggesting that gender does not serve as a moderating factor in the relationship between these variables among secondary school students in Bayelsa State.

Discussion of Findings

The finding that students' proficiency in mathematical construction skills significantly predicts their achievement in biology among secondary school students in Bayelsa State aligns with prior research emphasizing the interdependence of mathematical reasoning and scientific understanding. According to Achor and Ejigbo (2019), mathematical skills such as measurement, spatial visualization, and logical reasoning are foundational to interpreting and analyzing biological data, particularly in areas like genetics, ecology, and physiology. Similarly, Adeyemi (2021) observed that students with strong mathematical construction abilities tend to perform better in science

subjects because they can conceptualize abstract scientific phenomena quantitatively. This study's result, showing a moderate positive correlation ($\beta = 0.590$, $p < 0.05$), reinforces the assertion of Uzoegwu and Ezeudu (2020) that proficiency in mathematical construction enhances students' accuracy and confidence in solving problem-based tasks in science disciplines. Moreover, the finding supports the constructivist learning theory, which posits that knowledge acquisition occurs through active engagement and the integration of related cognitive domains (Piaget, 1972). Hence, the result implies that strengthening students' mathematical construction skills could enhance their academic performance in biology by promoting critical thinking, problem-solving, and analytical reasoning capabilities essential for understanding complex biological processes.

The finding that gender does not significantly influence the predictive relationship between students' mathematical construction skills and their achievement in biology among secondary school students in Bayelsa State is consistent with earlier research suggesting minimal gender disparities in academic performance when equal learning opportunities are provided. According to Eze and Okeke (2020), both male and female students demonstrate comparable cognitive abilities in applying mathematical reasoning to scientific problem-solving when exposed to similar instructional conditions. This outcome corroborates the report by Yusuf and Afolabi (2019), which indicated that gender differences in mathematics and science achievement have become increasingly insignificant due to improved pedagogical practices and equitable classroom participation. Likewise, Olatunji (2021) found that achievement in science-related subjects is more strongly influenced by individual interest, effort, and teacher effectiveness than by gender. The present study, therefore, supports the position of Ogunleye and Adebayo (2022) that gender should not be considered a determining factor in predicting students' academic success in science, as both males and females possess equal potential to develop mathematical and analytical competencies

necessary for understanding biological concepts. This finding emphasizes the importance of adopting gender-inclusive instructional strategies that foster equal participation and competence development among all learners.

Conclusion

Based on the findings of this study, it is concluded that students' proficiency in mathematical construction skills serves as a significant predictor of their academic achievement in biology among secondary school students in Bayelsa State, while gender does not significantly influence this predictive relationship. This suggests that the ability to apply mathematical reasoning and construction techniques enhances students' comprehension and performance in biology, irrespective of gender differences. The result underscores the need for educators to integrate mathematical skill development into biology instruction to foster deeper conceptual understanding and problem-solving ability. Furthermore, the finding reinforces the importance of providing equitable learning opportunities and adopting gender-neutral pedagogical approaches that promote equal access to quality instruction, thereby ensuring that both male and female students can reach their full academic potential in science-related subjects.

Recommendations

Based on the findings of the study, the following recommendations were given:

1. Teachers of biology should incorporate mathematical construction activities into their instructional strategies to enhance students' analytical and problem-solving skills, thereby improving their academic achievement in biology.
2. School administrators and policymakers should promote gender-inclusive teaching practices and provide equal access to learning resources to ensure that both male and female students develop comparable competencies in mathematics and science-related subjects.

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