



Effect of Visual Models on Students' Achievement in Mammalian Skeleton Among Secondary School Students in Delta State

Rita Akpobome OGUOKO & Josiah Oghenetega ORIOGWHO

Department of Curriculum and Instructional Technology, Faculty of Education, University of Benin, Benin City, Edo State

Corresponding Author: ritaakpobomeoguoko@gmail.com

Abstract

This research used a quasi-experimental approach with pretest posttest non-equivalent control groups to investigate how visual representations affected students' achievement in the mammalian skeleton. The inquiry was led by two hypotheses and two research questions. 92 participant were selected from the study population, which consisted of 562 SS1 students in Delta State's Bomadi Local Government Area. According to the Kuder Richardson Formula 20 (KR-20), the Mammalian Skeleton Student Achievement Test (MSSAT), which was used to gather the data, has a reliability coefficient of 0.74. Analysis of Covariance (ANCOVA) was used to examine the data at the significance level of 0.05. Findings demonstrated that students taught using visual models achieved better than those taught via the lecture technique. However, when teaching using visual models, there was no discernible difference in the achievement of male and female students. The research suggests that education stakeholders provide these teaching materials in schools and that biology instructors use visual models to enhance learning.

Keywords: Achievement, Visual Models, Gender, Mammalian Skeleton,

Introduction

Biology students' consistently low achievement has frequently been attributed to the use of abstract teaching strategies that do not actively engage students, particularly in difficult courses like the mammalian skeletal system. Examining the effects of visual models, including diagrams, three-dimensional structures, and concrete skeleton replicas, on the academic achievement of Delta State secondary school students was the aim of this study. Finding out if these instructional resources might enhance skeletal idea achievement and mastery more effectively than conventional lecture-based methods was the aim. The study aims to promote improved teaching methods in biology and science education in general by emphasizing the use of visual models.

Biology is a natural science that examines the composition, roles, growth, evolution, classification, and interactions of living organisms with their environment. Students with a strong biological foundation are more adept at using scientific reasoning to solve practical issues. The subject is still crucial in

fields including medicine, pharmacy, anatomy, physiology, agriculture, biotechnology, and the extractive industries. In Nigeria, biology is one of the most popular subjects on the West African Senior School Certificate Examination (WASSCE) and an essential science course at the senior secondary level (WAEC, 2022).

Achievement is still below expectations despite this high enrollment, particularly in areas that call for conceptual knowledge (Adeboye & Oyetunde, 2019). Studies show that students frequently have trouble understanding concepts like cell division, respiration, photosynthesis, genetics, skeletal systems, and ecological links (Okebukola, 2005; Ezeudu & Obi, 2013). Along with the abstract nature of the sciences, these challenges are brought on by inadequate laboratory competence, subpar teaching materials, and teacher-centered teaching methodologies (Nwagbo & Obiekwe, 2010). According to Piaget and Ausubel's theories of cognitive learning, students' struggles with complex material are frequently caused by gaps in their

prior knowledge and developmental readiness (Obioma & Ohuche, 2005).

According to cognitive learning theories, students must be intellectually prepared and possess prior knowledge in order to properly comprehend challenging subjects. If these requirements are not fulfilled, confusion and misunderstanding are likely to occur. As a result, instructional models and visual models are crucial since they simplify abstract concepts. Using well-designed models and diagrams may help make abstract concepts more physical, resulting in more meaningful and intelligible learning experiences, especially in biology, where a knowledge of spatial linkages and structures is crucial.

Inquiry-driven, interactive, and visual learning approaches help students grasp things more thoroughly and remember them over time, according to a growing body of research. Nonetheless, biology education in many Nigerian secondary schools continues to mostly consist on traditional lecture-based methods (Aina, 2013; Aliu, 2015).

A teacher-centered "lecture" method is frequently employed to educate, with students largely passively absorbing information with minimal active engagement. These approaches restrict students' exposure to visual materials and their capacity for active participation, which hinders their understanding of crucial biological concepts.

Because biology is so important to the nation's progress and because students consistently do poorly in important topics, it is critical to identify the specific concepts that provide challenges and look into possible remedies through improved teaching strategies. Reports from the WAEC Chief Examiners in 2021 indicate that Delta State students frequently exhibit poor achievement and misapply biological concepts during exams.

This trend emphasizes the need to investigate if using visual models could improve secondary school students' understanding of biological concepts like the mammalian skeleton.

Omemu (2018) defines academic achievement as the degree to which students achieve preset learning objectives in organized learning settings. Similarly, the Oxford Advanced Learner's Dictionary defines achievement as the achievement completion of a standard or goal via consistent effort. The level of information and skill students acquire in biology is reflected in their academic achievement. If educators wish to increase student achievement, they must employ a range of instructional techniques that promote

meaningful learning and aid students in developing a deeper understanding of biological subjects. Individual differences like gender may have an impact on how students engage with instructional materials.

Examples of visual models that might help balance these differences and encourage more equitable learning outcomes are models and diagrams. Obioma and Ohuche (2005) noted that both male and female students benefit from the use of pictures, however the type and degree of the advantages may differ. For example, research suggests that male learners may have more spatial thinking, which enables them to interpret complex diagrams, while female learners may respond better to structured visual models that emphasize achievement over memorization (Halpern, 2012).

This raises a crucial question: Do visual models have an equal impact on all students, or do gender-specific responses produce different outcomes? Although gender disparities in scientific achievement are frequently emphasized, few studies specifically look at how male and female students interact with visual representations in biology. The study of the mammalian skeleton is particularly relevant since it calls for visual achievement and spatial awareness, but little is known about how gender influences these abilities.

This study attempts to bridge that gap by examining gender differences and the influence of visual models on students' understanding of concepts related to mammalian skeletons. By including gender as a variable, the research hopes to present a more complete picture of equality and effectiveness in scientific training. This assertion is supported by Muhammad, Ya'u, Aliyu, and Hassan (2018), who contend that visual models are crucial for addressing instructional difficulties. According to some accounts, Benjamin Franklin said, "Tell me and I forget, teach me and I may remember, involve me and I learn." This well-known quotation highlights the need of active engagement. Passive listening seldom results in learning that lasts, while interactive strategies like the use of visual models enhance achievement and retention.

In conclusion, despite the continued existence of gender-related disparities in scientific education, visual teaching methods have the potential to increase achievement for all students. Thus, this study investigates whether the benefits of visual models that are gender-neutral remain constant or if alternative strategies are required. It aims to offer context-specific, evidence-based insights that will direct curriculum development, teacher preparation, and gender-sensitive

teaching strategies by focusing on secondary schools in Nigeria. The findings are expected to improve biology achievement and promote gender-responsive education in the region.

Research Questions

The following research questions guided the study

1. What is the difference between students who were taught the concept of the mammalian skeleton through the use of visual models and those who were taught through lectures in terms of their mean achievement scores?
2. How do male and female students' mean achievement scores change when they are taught the concept of the mammalian skeleton through visual models?

Research Hypotheses

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

1. Students who were taught the concept of the mammalian skeleton through visual models and those who were taught it through lectures did not significantly differ in their mean achievement scores.
2. The mean achievement scores of male and female students who were taught the concept of

the mammalian skeleton via visual models did not differ significantly.

Methodology

This study used a quasi-experimental pretest and posttest design with non-equivalent control groups. 562 SS1 students in Delta State's Bomadi Local Government Area made up the target demographic. Purposive and simple random sampling technique was used to choose 92 students from two secondary schools from this group. While the control group received lectures, the experimental group, which consisted of one school, used visual models such as charts and skeleton models to teach its students.

Mammalian Skeleton Student Achievement Test (MSSAT) questions from previous standardized tests were used to build the instrument use for data gathering. There are four possible answers to the multiple-choice exam. A table of specifications and an expert evaluation were used to verify the instrument. The Kuder–Richardson Formula 20 (KR-20), which produced a coefficient of 0.74, was used to illustrate reliability. The instrument was used as pretest for the two group. After a four-week educational intervention, the instrument was given as a pretest and a posttest. To achieve the study's objectives, the data was analyzed using mean and standard deviation, and the hypotheses were evaluated using Analysis of Covariance (ANCOVA) at a 0.05 significant level.

Results and Table

H₀₁: Students who were taught the concept of the mammalian skeleton through visual models and those who were taught it through lectures did not significantly differ in their mean achievement scores

Table 1: Pretest and Posttest Mean Achievement Scores and Standard Deviation of the Experimental and Control Groups

Group	N	Pretest \bar{x}	SD	Posttest \bar{x}	SD	Mean Gain
Experimental	45	3.04	0.78	3.28	0.78	0.24
Control	47	3.16	0.46	3.20	0.79	0.04

The descriptive data for the experimental and control groups' mean scores, standard deviations, and mean increases are shown in Table 1. According to the results, the experimental group's mean score on the pretest was 3.04, and their posttest score rose to 3.28, resulting in a mean gain of 0.24. On the other hand, the

control group's minimal mean gain was 0.04 and their pretest and posttest means were 3.16 and 3.20, respectively. These results show that students who were taught using visual models outperformed those who were taught using the traditional lecture technique in terms of achievement improvement.

Table 2: One Way ANCOVA Result of the Posttest Achievement Scores of Biology Students in the Experimental and Control Groups

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7.192	1	7.192	20.25	.000
Intercept	171.279	1	171.279	482.17	.000
Groups	7.192	1	7.192	20.25	.002
Error	31.971	90	0.355		
Total	209.000	92			
Corrected Total	39.163	91			

a. R Squared = .184 (Adjusted R Squared = .175)

Even after controlling for pretest achievement, Table 2's ANCOVA results show that the usage of visual models significantly impacted students' posttest achievement scores. In particular, students who were taught the mammalian skeletal concept via visual models did better than those who were taught it through standard lecture-based education ($F(1,90) = 20.247$, $p = .002$), which is significantly below the significance

level of 05. The null hypothesis was thus disproved, indicating that the teaching strategy had a significant impact on student achievement. Additionally, according to the stated impact size ($R^2 = .184$), the teaching strategy used accounts for around 18.4% of the variation in achievement results.

H_{02} : The mean achievement scores of male and female students who were taught the concept of the mammalian skeleton via visual models did not differ significantly.

Table 3: Pretest and Posttest Mean Achievement Scores and Standard Deviation of the Males and Females of the Experimental Group

Groups	N	Pretest \bar{x}	SD	Posttest \bar{x}	SD	Mean Gain
Male	20	3.63	0.49	3.76	0.51	0.13
Female	25	3.16	0.61	3.24	0.65	0.08

The experimental group's male and female students' mean achievement scores, standard deviations, and mean increases are shown in Table 3. The posttest mean score for males was 3.76 with a standard deviation of 0.51, whereas the posttest mean score for females was 3.24 with a standard deviation of

0.65. Males had a mean gain of 0.13, while females had a mean gain of 0.08. There is a little variation in mean gain, but it is not statistically significant. These data demonstrate that gender did not have a significant influence on students' achievement when model-based learning was applied.

Table 4: One Way ANCOVA Result of the Posttest Achievement Scores of the Males and Females of the Experimental Group

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.791 ^a	1	1.791	4.31	.041
Intercept	149.617	1	149.617	360.31	.000
SEX	1.791	1	1.791	4.313	.132
Error	37.372	90	.415		
Total	209.000	92			
Corrected Total	39.163	91			

a. R Squared = .046 (Adjusted R Squared = .035)

The mean achievement scores of male and female students taught using visual models did not differ significantly, according to the ANCOVA result in Table 4 ($F(1,90) = 4.313, p = .132 > .05$). Therefore, the null hypothesis was retained. This suggests that while teaching with visual models, students' achievement was not greatly impacted by gender.

Discussion of Findings

The results of the study demonstrated that students who were taught via visual models achieved better than those who were taught through lectures, suggesting that biology students gain from visual models. Omariba's (2017) results that real-world specimens increase interest and learning outcomes are supported by this. Therefore, the use of visual models is necessary to increase student achievement in biology classes.

The findings showed no significant differences in the achievement of male and female students exposed to visual models. This implies that teaching that includes visual models is equally beneficial for both sexes.

This result is consistent with that of Enohuan (2015), who discovered no gender-based differences in biology proficiency while using educational resources. Therefore, when using visual models, gender does not seem to be a predictor of achievement.

Conclusion

According to this study, the use of visual models greatly enhances students' achievement in biology courses pertaining to mammalian skeletons, even if gender has no effect on learning outcomes under this approach. The findings highlight how crucial it is to incorporate a range of visual representations into biology lessons in order to raise secondary school students' academic achievement.

Contribution to Knowledge

This study contributes to the body of knowledge by providing concrete evidence that visual models significantly enhance biology students' academic achievement, particularly in understanding the mammalian skeleton. Additionally, it elucidates the connection between gender and instructional strategies, offering crucial details for developing equitable teaching methods. For biology instructors, curriculum developers, and lawmakers looking to improve the standard of scientific education in Nigeria and similar contexts, the findings offer helpful guidance.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. The Ministry of Education should prioritize the provision of visual representations in order to support the effective teaching and learning of biological concepts in secondary schools.
2. Biology teachers should employ a variety of lab-based methods and visual models in their lessons to increase student achievement.
3. Other stakeholders, such as alumni associations, Parent-Teacher organizations (PTAs), and Non-Governmental associations (NGOs), might also contribute by giving schools visual models and related instructional resources.

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