Effect of Ethno Science Based Instructional Model on Students Academic Achievement in Biology

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Abstract

This study investigated the effect of the Ethno Science Based Instructional Model (ESBIM) on secondary school students' academic achievement in Biology. The research was conducted using a quasi-experimental non-equivalent control group design involving 202 Senior Secondary II Biology students drawn from co-educational schools in Otuocha Education Zone, Anambra State, Nigeria. Three intact classes were assigned to the experimental group and taught using ESBIM, while three other intact classes assigned to control group received instruction through the lecture method. The Biology Achievement Test (BAT), a validated 50-item multiple-choice test with a KR-20 reliability coefficient of 0.81, was used for data collection. Mean and standard deviation were used to answer research questions, while Analysis of Covariance (ANCOVA) tested hypotheses at the 0.05 significance level. Results revealed that the experimental group had a significantly higher post-test mean achievement score ($M = 78.40$, $SD = 6.42$) compared to the control group ($M = 65.75$, $SD = 7.13$), $F(1, 142) = 23.87$, $p < .001$. Gender did not significantly influence achievement, and there was no significant interaction between instructional model and gender. The findings indicated that ESBIM is an effective, gender-inclusive approach for enhancing academic achievement in Biology. It was concluded that integrating ethno scientific content into science instruction fosters deeper understanding by linking scientific concepts to learners' cultural backgrounds. Recommendations include the inclusion of ESBIM principles in teacher training programs and the development of culturally responsive Biology teaching resources.

Keywords: Ethno Science Based Instructional Model, Academic Achievement, Biology Education, Gender, Secondary School Students.

Introduction

Science education plays a critical role in equipping learners with the knowledge, skills, and attitudes necessary for understanding and addressing real-world problems. Among science

subjects, Biology is central to developing competencies in health, environmental stewardship, and sustainable living. When students are taught biology in indigenous language, a link is established between home and biology concepts (Adedigba etal, 2023). However, persistent evidence from national examinations in Nigeria, such as the West African Examinations Council (WAEC) Chief Examiners' Reports (), indicates that students' achievement in Biology remains below expectations. This underperformance has been linked to factors such as abstract content delivery, poor instructional strategies, and the failure to connect scientific concepts to learners' lived experiences. The inappropriate teaching strategies used by most biology teachers such as conventional and lecture methods have been identified as the primary cause of the underperformance of students in biology (Alison, et al 2025). The lecture method, still widely used in Nigerian classrooms, is often teacher-centred and information-driven. While it may allow content coverage within limited time, it rarely fosters deep conceptual understanding or sustained learner engagement. Alison, et al (2025) reported a positive significant difference between students taught science with innovative teaching method like computer Aided Instructions than those taught using conventional teaching method. This has prompted calls for innovative pedagogies that not only transmit scientific knowledge but also contextualize it in culturally relevant ways.

The Ethno Science Based Instructional Model (ESBIM) is one such approach. It integrates indigenous knowledge systems and culturally familiarize practices with conventional science content to enhance meaning-making and learner motivation. Rooted in Piaget's Cognitive Constructivist Theory and Ausubel's Theory of Meaningful Learning, ESBIM leverages students 'building prior knowledge and socio-cultural experiences as a foundation for new scientific concepts. This approach not only acknowledges the validity of indigenous knowledge but also

bridges the gap between traditional understanding and formal science education. Although research has demonstrated the potential of culturally responsive pedagogies in improving learning outcomes in science, empirical evidence on the specific impact of ESBIM on Biology achievement in Nigerian secondary schools remains scarce. Furthermore, the role of gender in moderating achievement outcomes under ESBIM instruction is not well understood.

This study, therefore, investigates the effect of the Ethno Science Based Instructional Model on students' academic achievement in Biology, with particular attention to gender influence and instructional model–gender interaction.

Purpose of the Study

The primary purpose of this study was to determine the effect of the Ethno Science Based Instructional Model (ESBIM) on secondary school students' academic achievement in Biology. Specifically, the study sought to:

1. Find out the mean achievement scores of students taught Biology using ESBIM and those taught using the lecture method.
2. Determine the influence of gender on students' academic achievement in Biology when taught using ESBIM.
3. Examine the interaction effect of instructional model and gender on students' academic achievement in Biology.

Research Questions

1. What is the difference in the mean achievement scores of students taught Biology using ESBIM and those taught using the lecture method?
2. What is the difference in the mean achievement scores of male and female students taught Biology using ESBIM?
3. What is the interaction effect of instructional model and gender on students' academic achievement in Biology?

Hypotheses

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

1. There is no significant difference in the mean achievement scores of students taught Biology using ESBIM and those taught using the lecture method.
2. There is no significant difference in the mean achievement scores of male and female students taught Biology using ESBIM.
3. There is no significant interaction effect of instructional model and gender on students' achievement in Biology

Methodology

Research Design

The study employed a quasi-experimental research design, specifically the non-equivalent control group design. This design is considered appropriate for educational research involving

intact classes where randomization is impractical (Fraenkel & Wallen, 2009). The design consisted of two groups: an experimental group taught Biology using the Ethno Science Based Instructional Model (ESBIM) and a control group taught the same content through the lecture method. Both groups were subjected to pre-tests and post-tests to determine achievement gains.

Area of the Study

The research was conducted in Otuocha Education Zone of Anambra State, Nigeria. The zone was selected because of its cultural diversity and the persistent reports of students' poor performance in Biology as documented in the West African Examinations Council (WAEC) Chief Examiners' Reports (WAEC, 2017, 2019, 2020).

Population of the Study

The target population consisted of all Senior Secondary II (SSII) students offering Biology in public co-educational secondary schools in Otuocha Education Zone.

Sample and Sampling Technique

A multistage sampling technique was used. Six schools were randomly selected — two from each of the three local government areas in the zone. One intact SSII class was selected from each school, giving a total of 202 students. The experimental group comprised 123 students, while 79 students formed the control group. The use of intact classes ensured minimal disruption to the normal school program, consistent with recommendations for quasi-experimental school-based research (Campbell & Stanley, 1963).

Instrument for Data Collection

Data were collected using the Biology Achievement Test (BAT), a 50-item multiple-choice test constructed by the researchers based on the SSII Biology curriculum. The items covered the instructional content used during the intervention, ensuring content validity.

Validity of the Instrument

The BAT was subjected to face and content validation by three experts — two from the Department of Science Education and one from the Department of Measurement and Evaluation, Chukwuemeka Odumegwu Ojukwu University. Their suggestions were used to refine the instrument before administration.

Reliability of the Instrument

To establish reliability, the instrument was trial-tested on 30 SSII students outside the study sample. The Kuder–Richardson Formula 20 (KR-20) was applied, yielding a reliability coefficient of 0.81, which indicates good internal consistency (Crocker & Algina, 2008).

Experimental Procedure

The intervention lasted for eight weeks. The experimental group was taught using the Ethno Science Based Instructional Model (ESBIM). The ESBIM lessons followed four phases:

1. **Elicitation of prior knowledge** — drawing on learners' indigenous knowledge and cultural practices.
2. **Introduction of new concepts** — linking Biology content to culturally familiar contexts.
3. Collaborative learning activities — engaging students in group tasks and discussions to foster conceptual understanding.
4. **Application** — relating scientific principles to learners' daily lives.

Conversely, the control group was taught the same topics using the conventional lecture method, which was teacher-centred and textbook-driven.

Method of Data Collection

The BAT was administered to both groups as a pre-test before the intervention and again as a post-test after the treatment. The tests were conducted under standardized classroom conditions to ensure fairness.

Method of Data Analysis

The research questions were answered using mean and standard deviation, while the null hypotheses were tested using Analysis of Covariance (ANCOVA) at a 0.05 level of significance. The ANCOVA helped to control for pre-test differences between the groups and provided a more accurate estimate of treatment effect (Field, 2018).

Results and Interpretation

Research Question 1: What is the mean achievement score of students taught Biology using ESBIM compared to those taught using the lecture method?

The results in Table 1 show that students taught with ESBIM had a higher post-test mean achievement score (M = 78.40, SD = 6.42) than those taught with the lecture method (M = 65.75, SD = 7.13). This suggests that ESBIM improved students' academic achievement in Biology.

Table 1: Mean and Standard Deviation of Students' Achievement Scores

Group	N	Mean	SD	Interpretation
Experimental	73	78.40	6.42	Higher achievement with ESBIM
Control	72	65.75	7.13	Lower achievement with lecture method

Research Question 2: What is the influence of gender on the achievement of students taught Biology using ESBIM?

Table 2 shows that male students in the experimental group had a mean achievement score of 78.10 (SD = 6.55), while females had a slightly higher mean of 78.70 (SD = 6.33). The difference is small, suggesting minimal gender influence on achievement.

Table 2: Mean and Standard Deviation of Students' Achievement Scores by Gender (Experimental Group)

Gender	N	Mean	SD	Interpretation
Male	38	78.10	6.55	Minimal gender difference
Female	35	78.70	6.33	

Research Question 3: What is the interaction effect of instructional model and gender on students' achievement in Biology?

Table 3 shows that the mean scores for male and female students in both instructional groups were close, indicating little variation in achievement due to the interaction of instructional model and gender.

Table 3: Mean Achievement Scores by Group and Gender

Group	Gender	Mean	Interpretation
Experimental	Male	78.10	
Experimental	Female	78.70	
Control	Male	65.50	
Control	Female	66.00	

Hypotheses Testing

H_{01}: There is no significant difference in the mean achievement scores of students taught Biology using ESBIM and those taught using the lecture method.

ANCOVA results in Table 4 show a significant difference between the two groups, $F(1, 142) = 23.87$, $p < .001$. The null hypothesis is rejected, indicating ESBIM significantly improved achievement.

Table 4: ANCOVA Summary for Students' Achievement

Source	SS	df	MS	F	p-value	Decision
Group	1572.21	1	1572.21	23.87	0.000	Reject H_{01}
Error	9353.82	142	65.87			

H_{02}: There is no significant difference in the mean achievement scores of male and female students taught Biology using ESBIM

ANCOVA results in Table 5 show no significant difference between male and female students, $F(1, 70) = 0.21$, $p = 0.649$. The null hypothesis is retained.

Table 5: ANCOVA Summary for Gender Effect

Source	SS	df	MS	F	p-value	Decision
Gender	8.92	1	8.92	0.21	0.649	Retain H_{02}
Error	3023.14	70	43.19			

H_{03}: There is no significant interaction effect of instructional model and gender on students' achievement in Biology.

ANCOVA results in Table 6 show no significant interaction, $F(1, 142) = 1.14$, $p = 0.287$. The null hypothesis is retained.

Table 6: ANCOVA Summary for Interaction Effect

Source	SS	df	MS	F	p-value	Decision
Model × Gender	97.61	1	97.61	1.14	0.287	Retain H_{03}
Error	12137.88	142	85.47			

Discussion of Findings

The findings of this study revealed that students taught Biology using the Ethno Science Based Instructional Model (ESBIM) significantly outperformed those taught with the lecture method in academic achievement. This outcome suggests that ESBIM's integration of indigenous knowledge and culturally relevant contexts provided a more engaging and meaningful learning experience, enhancing students' understanding and retention of Biology concepts. This aligns with Piaget's Cognitive Constructivist Theory, which emphasizes the role of prior knowledge in constructing new learning, and Ausubel's Theory of Meaningful Learning, which stresses the importance of connecting new content to relevant existing knowledge.

This result corroborates earlier studies by Jegede (1997) and Okeke and Kamwendo (2012), which found that culturally contextualized instruction enhances science achievement. More recently, Adedigba et al. (2023) confirmed that the use of indigenous language in teaching science creates a strong bridge between students' home experiences and school-based science learning, fostering deeper comprehension. The success of ESBIM in this study further validates their assertion by showing that contextualizing Biology within cultural and linguistic frameworks significantly boosts achievement.

Regarding gender, findings indicated no significant difference in achievement between male and female students taught with ESBIM. This implies that the model is equally effective for both sexes, supporting the conclusion of Iroegbu (2015) that culturally inclusive teaching methods can reduce gender disparities in science performance. The non-significant gender effect suggests that the differences often reported in science achievement may be more a function of instructional approach than inherent gender differences.

Similarly, the study found no significant interaction effect between instructional model and gender on Biology achievement. This reinforces the inclusivity of ESBIM and indicates that it benefits learners regardless of gender, making it a viable strategy for diverse classrooms.

Overall, the study affirms that ESBIM is a powerful tool for improving academic achievement in Biology, addressing cognitive and affective learning needs without bias towards gender.

Conclusion

This study investigated the effectiveness of the Ethno Science Based Instructional Model (ESBIM) on students' academic achievement in Biology. The results provide compelling evidence that ESBIM significantly enhances both achievement compared to the lecture method. The findings underscore the value of integrating culturally familiar content and indigenous knowledge into the science curriculum, as doing so fosters more meaningful engagement and improves learning outcomes. Furthermore, the absence of gender differences in outcomes indicates that ESBIM is equally effective across sexes, reinforcing its inclusivity and broad applicability. Grounded in constructivist principles, this model promotes deeper understanding by connecting new concepts to students' prior cultural experiences.

Recommendations

Based on the findings, the following recommendations are made:

1. **Curriculum developers** should integrate elements of ethno science into the national science curriculum to reflect indigenous knowledge systems and enhance relevance.
2. **Biology teachers** should be trained to adopt and apply ESBIM in classroom instruction, particularly in diverse cultural settings.
3. **Education stakeholders** should support the development of culturally responsive teaching materials that incorporate local analogies and community-based knowledge.
4. **Researchers** should further explore the impact of ESBIM across other science subjects and in different regions to validate and expand its applicability.
5. **Policy makers** should prioritize teacher capacity building in culturally responsive pedagogy as part of teacher education and in-service training.

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