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Effects of Blended Learning and Guided Inquiry on Students' Academic Achievement in Biology in Delta State

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Keywords

Blended learning, Guided inquiry, Biology, academic achievement, Gender differences.

Abstract

This study investigated the effects of blended learning and guided inquiry on the academic achievement of secondary school students in Biology in Delta State, Nigeria. The study adopted a quasi-experimental pretest-posttest control group design involving 214 senior secondary students from six public schools. The participants were divided into three groups and taught using blended learning, guided inquiry, and lecture methods, respectively. Data were collected using a Biology Achievement Test (BAT) and analyzed using mean, ANCOVA and post hoc tests. The findings revealed significant differences in the mean achievement scores of students across the three instructional strategies, with blended learning being the most effective, followed by guided inquiry, and then the lecture method. Post hoc analysis showed that students taught using blended learning performed significantly better than those taught using guided inquiry and lecture methods. However, no significant gender differences were found in achievement among students exposed to either blended learning or guided inquiry. These results highlight the need to promote modern, student-centered instructional approaches in Biology classrooms to enhance learning outcomes and bridge pedagogical and gender-related gaps. Recommendations were made to support the integration of blended and inquiry-based teaching methods in secondary school science education.

Introduction

Biology is the scientific study of life and living organisms, encompassing their structure, function, growth, evolution, distribution, and interrelationships with one another and their environments. It provides foundational knowledge about the natural world and helps explain how living systems operate at cellular, organismal, and ecosystem levels (Campbell et al., 2021). The teaching of Biology at the secondary school level is essential for several reasons. Firstly, it equips students with scientific literacy, enabling them to understand and make informed decisions about health, environment, and biotechnology-related issues in their daily lives (Okebukola, 2022). Secondly, Biology lays the groundwork for careers in medicine, agriculture, pharmacy, nursing, environmental science, and other life sciences, thus contributing to national development and the healthcare workforce (Adebayo & Onuoha, 2023). Thirdly, it fosters critical thinking and problem-solving skills through practical experiments and observations, aligning with global educational goals that emphasize inquiry-based and student-centered learning. Teaching Biology also promotes awareness of the need for environmental sustainability, conservation of biodiversity, and responsible use of natural resources—issues that are increasingly relevant in the face of climate change and public health challenges.

Despite these critical roles, the teaching and learning of Biology at the secondary school level in Nigeria, particularly in Delta State, remain a subject of concern due to persistently low student achievement and declining interest in the subject. These challenges are particularly alarming given the centrality of Biology in equipping students with scientific competencies. Evidence from internal and

external examinations shows that students' performance has consistently fallen below expectations (Nwokocha & Amadi, 2022). This underperformance has been largely attributed to the continued use of traditional teaching approaches such as the lecture method. As a teacher-centered strategy, the lecture method often disengages learners from active participation, fosters rote memorization, and fails to accommodate different learning styles (Odeh et al., 2023). Consequently, students are not sufficiently challenged to develop the critical thinking and analytical skills that modern Biology demands (Onah & Eze, 2021).

This pedagogical gap is further supported by empirical studies that have consistently linked students' poor achievement in Biology to the instructional strategies employed in its delivery (Adepoju & Ogundele, 2020; Igbokwe & Chike-Okoli, 2021). While the content of the Biology curriculum is rich and relevant, its impact is diminished when not delivered through engaging, interactive, and technology-enhanced approaches. In the context of 21st-century learning, where digital literacy and technological integration are crucial, continued reliance on outdated teaching methods puts students at a disadvantage—particularly when compared to their peers in more digitally advanced educational settings (Ekpenyong et al., 2024). This situation calls for a paradigm shift in instructional delivery, emphasizing the adoption of innovative pedagogies that can reinvigorate student interest and enhance comprehension in Biology.

One such approach is blended learning, which combines face-to-face instruction with online and technology-mediated components. This hybrid model enables students to interact with content through multiple modalities, such as simulations, animations, and digital assessments, which are particularly effective in simplifying complex biological concepts (Abdullahi & Okonkwo, 2023). Blended learning also supports personalized learning, allowing students to progress at their own pace while benefiting from peer interaction and teacher support in a physical classroom. Studies have shown that students exposed to blended learning environments tend to demonstrate better understanding, higher engagement, and improved academic outcomes compared to those taught using traditional methods (Ibrahim & Musa, 2022). However, in Delta State, the use of blended learning remains minimal, limited by infrastructural deficits, insufficient teacher training, and a lack of coherent policy implementation. This underutilization deprives students of a more dynamic and responsive learning experience that could substantially improve their academic performance in Biology.

Similarly, guided inquiry represents another promising learner-centered strategy that addresses the limitations of conventional teaching. In this method, students actively engage in scientific investigation by asking questions, collecting and analyzing data, and drawing conclusions under the teacher's guidance. This approach not only nurtures curiosity and scientific reasoning but also aligns with the constructivist theory of learning, where students construct knowledge through exploration and reflection (Chukwu & Afolabi, 2021). Unlike passive learning environments, guided inquiry positions students as co-creators of knowledge, promoting deeper cognitive engagement and long-term retention of content. Research has confirmed that students taught through guided inquiry tend to perform better and develop more positive attitudes toward science than those instructed through traditional lectures (Okoh & Nwanne, 2024). Furthermore, guided inquiry fosters essential 21st-century skills such as collaboration, communication, and critical thinking. Nevertheless, its implementation in Nigerian classrooms remains limited, often hindered by overcrowded classrooms, rigid curricula, and a shortage of trained personnel.

These pedagogical challenges are further compounded by the persistent issue of gender disparities in science education. Although Biology is generally viewed as gender-neutral, research continues to report mixed outcomes regarding male and female students' academic performance. Some studies indicate that female students outperform their male peers due to stronger reading habits and attentiveness (Chidiebere & Adeyemi, 2021), while others attribute higher male performance to

confidence levels and socio-cultural support for science-related pursuits (Abubakar & Olaniyi, 2022). These conflicting findings suggest that contextual factors—such as teacher expectations, classroom dynamics, and access to learning resources—play a significant role in shaping gendered outcomes in Biology achievement (Eze & Okolie, 2023). Understanding how these factors interact with instructional strategies is crucial for promoting gender equity in science education.

Moreover, the instructional methods employed can either mitigate or exacerbate these gender disparities. Traditional, competitive, and lecture-based models tend to favour male students, while student-centered and collaborative approaches—such as blended learning and guided inquiry—provide a more balanced and inclusive environment that supports the learning needs of both genders (Okoye & Oloyede, 2023). Investigating how these innovative instructional strategies impact male and female students differently is essential for developing interventions that close performance gaps and promote equal opportunities. Without such targeted efforts, efforts to improve academic achievement in Biology may fail to achieve inclusive educational outcomes.

The continued reliance on outdated instructional strategies, minimal integration of technology, and limited use of inquiry-based methods poses a significant threat to the quality of Biology education in Delta State. These challenges not only hinder students' academic performance but also impair their preparedness for higher education and careers in STEM fields. Left unaddressed, this situation could result in a generation of learners ill-equipped to meet the scientific and technological demands of modern society. Therefore, there is a pressing need to investigate and validate the effectiveness of innovative teaching strategies like blended learning and guided inquiry. This study is timely and essential as it seeks to explore how these pedagogical approaches can enhance students' academic achievement in Biology while addressing both instructional deficiencies and gender-related disparities in science education.

Statement of the Problem

Despite the central role of Biology in promoting scientific literacy, public health awareness, and national development, students' academic achievement in the subject at the secondary school level in Delta State remains consistently poor. Internal and external examination results continue to reveal low performance, indicating a disconnect between the objectives of Biology education and the actual learning outcomes. A major contributor to this persistent underachievement is the continued use of conventional, teacher-centered instructional strategies such as the lecture method. This method often promote rote learning, limit student engagement, and fail to accommodate diverse learning needs and styles, especially in a subject like Biology that demands critical thinking, hands-on investigation, and conceptual understanding.

Moreover, modern and innovative teaching strategies—particularly blended learning and guided inquiry—remain underutilized in many secondary schools within Delta State. Blended learning offers the advantage of combining face-to-face interaction with technology-enhanced instruction, while guided inquiry fosters active participation, scientific reasoning, and long-term content retention. Yet, their adoption is hindered by infrastructural challenges, lack of teacher preparedness, and systemic resistance to pedagogical change. Additionally, gender disparities in Biology performance persist, with male and female students being differentially affected by traditional teaching methods. If these issues remain unaddressed, the educational system risks producing students who are not only ill-prepared for higher education and science-related careers but also unable to contribute meaningfully to the nation's scientific and technological development. Therefore, there is an urgent need to empirically investigate how blended learning and guided inquiry could enhance students' academic achievement in Biology and promote gender-inclusive educational outcomes in Delta State.

Purpose of the Study

This study primarily examined how the use of blended learning and guided inquiry strategies impacts the academic performance of secondary school students in Biology in Delta State. Specifically, the study sought to:

1. examine whether there are significant differences in the mean achievement scores of students taught Biology using blended learning, guided inquiry, and the conventional lecture method;
2. investigate the variation in mean achievement scores between male and female students exposed to Biology instruction through blended learning;
3. explore the difference in mean achievement scores between male and female students taught Biology using guided inquiry strategy.

Research Questions

Based on the stated objectives, the following research questions guided the study:

1. What are the differences in mean achievement scores among students taught Biology using blended learning, guided inquiry, and lecture methods?
2. What difference exists between the mean achievement scores of male and female students taught Biology using blended learning?
3. What difference exists between the mean achievement scores of male and female students taught Biology using guided inquiry?

Hypotheses

The following null hypotheses were formulated to guide the study:

HO_1: There is no significant difference in the mean achievement scores of students taught Biology using blended learning, guided inquiry, and lecture methods.

HO_2: There is no significant difference between the mean achievement scores of male and female students taught Biology using blended learning.

HO_3: There is no significant difference between the mean achievement scores of male and female students taught Biology using guided inquiry.

Research Method

The study adopted a quasi-experimental research design, specifically the non-equivalent pretest-posttest control group design. This design was considered appropriate because it allows the researcher to investigate the effects of two different instructional strategies—blended learning and guided inquiry—on students' academic achievement in Biology, while using intact classes without random assignment. The design involved three groups: one experimental group was taught using blended learning, another experimental group was exposed to guided inquiry, and a control group was taught using the conventional lecture method. All groups were pretested before the intervention and posttested after the instructional period to assess the impact of the respective strategies on students' achievement.

The population of the study comprised all Senior Secondary Two (SS II) Biology students in public secondary schools in Delta State during the 2024/2025 academic session. This population was chosen because SS II students have been adequately exposed to foundational Biology content and are preparing for external assessments, making them suitable for measuring academic achievement outcomes. A multi-stage sampling technique was employed in selecting the sample for the study. First, three Local Government Areas (LGAs) were randomly selected from the state. Within each LGA, six co-educational public secondary schools with comparable facilities and qualified Biology teachers were

purposively selected. Finally, intact SSS II classes from the six selected schools were assigned to the three groups. A total of 214 students participated in the study.

The instrument used for data collection was the Biology Achievement Test (BAT), which was developed by the researcher from past WASSCE question papers based on selected topics from the SS II Biology curriculum. The BAT consisted of 50 multiple-choice items designed to measure students' knowledge, comprehension, application, and analysis skills in Biology. The instrument was subjected to face, content and construct validation. The face validity was established by three experts: one in Biology teacher, one science Educator, and one expert in measurement and evaluation in Delta State University in Abraka. Their feedback was used to refine the test items. A table of specification was used to established the content validity. As for the construct validity, the difficulty and discriminating indices were established. To determine the reliability of the instrument, it was administered to a sample of 30 SS II students in a school outside the study area, and the data were analyzed using the Kuder-Richardson Formula 20 (KR-20), which yielded a reliability coefficient of 0.87, indicating that the instrument was highly reliable.

The intervention lasted for six weeks. During the treatment period, the experimental groups were taught using the blended learning and guided inquiry strategies, respectively. The blended learning group received a combination of face-to-face instruction and digital resources, including video demonstrations, animations, and interactive quizzes delivered via an e-learning platform. The guided inquiry group was engaged in structured investigative tasks where they asked questions, conducted simple experiments, and drew conclusions with teacher guidance. The control group was taught using the traditional lecture method, where the teacher delivered the lessons orally, and students took notes with minimal interaction or experimentation. To ensure uniformity in lesson delivery, lesson plans were developed and reviewed for all three groups. Teachers who facilitated the lessons were trained for one week on how to effectively implement the instructional strategies assigned to their respective groups.

Data collection occurred in two phases: the pretest was administered to all groups before the commencement of the instructional treatment, and the posttest was administered at the end of the six-week intervention. The students' scores from the BAT were analyzed using both descriptive and inferential statistics. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at 0.05 level of significance. ANCOVA was considered appropriate for controlling initial group differences as reflected in the pretest scores, thereby isolating the effect of the instructional strategies on the posttest achievement scores. All data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 23.

Ethical considerations were strictly adhered to throughout the study. Permission was obtained from the appropriate educational authorities, and informed consent was secured from the school principals and Biology teachers involved. Confidentiality and anonymity were maintained by coding students' responses without revealing their identities. The study was designed to ensure minimal disruption to normal school activities while maintaining academic integrity and scientific rigor.

Results

- ✓ What are the differences in mean achievement scores among students taught Biology using blended learning, guided inquiry, and lecture methods?

Table 1: Mean Achievement Scores of Students Taught Biology Using Blended Learning, Guided Inquiry, and Lecture Method

Group	N	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
Blended learning	63	22.25	9.43	62.03	9.65	39.78
Guided inquiry	74	21.45	9.46	58.05	10.23	36.60
Lecture method	77	21.90	8.26	49.38	10.52	27.48

The descriptive statistics indicate that students exposed to blended learning achieved the highest mean gain of 39.78 in Biology scores, followed by those exposed to guided inquiry with a mean gain of 36.60, while students taught through the lecture method had the lowest mean gain of 27.48. This trend suggests that modern, student-centered teaching strategies such as blended learning and guided inquiry are more effective at improving academic achievement than the traditional lecture method.

✓ There is no significant difference in the mean achievement scores of students taught Biology using blended learning, guided inquiry, and lecture methods.

Table 2: ANCOVA Summary for the Effects of Teaching Method on Students' Biology Achievement Scores

Source	Type III SS	df	Mean Square	F	Sig.
Corrected Model	10235.459	3	3411.820	40.792	.000
Intercept	64091.182	1	64091.182	766.280	.000
Pretest	4255.519	1	4255.519	50.879	.000
Method	5917.041	2	2958.521	35.372	.000
Error	17564.279	210	83.639		
Total	701370.000	214			
Corrected Total	27799.738	213			

The ANCOVA results show a statistically significant effect of the teaching method on students' posttest achievement scores in Biology ($F(2, 210) = 35.372$, $p < .05$). After adjusting for pretest scores, the type of instructional method used had a significant impact on the students' performance. This provides strong evidence that the choice of teaching method affects learning outcomes in Biology.

Table 3: Post Hoc Multiple Comparisons (Bonferroni) of Achievement Scores by Teaching Method

(I) Teaching Method	(J) Teaching Method	Mean Difference (I-J)	Std. Error	Sig.	95% CI Lower	95% CI Upper
Blended Learning	Guided Inquiry	3.576*	1.569	.024	0.483	6.669
Blended Learning	Lecture Method	12.477*	1.554	.000	9.414	15.540
Guided Inquiry	Lecture Method	8.901*	1.489	.000	5.966	11.837

The post hoc comparisons in Table 3 indicate that blended learning significantly outperformed guided inquiry ($p = .024$). Both blended learning and guided inquiry significantly outperformed the lecture method ($p = .000$ in both cases). These findings confirm that blended learning is the most effective of the three strategies in enhancing students' academic achievement in Biology, followed by guided inquiry.

✓ What difference exists between the mean achievement scores of male and female students taught Biology using blended learning?

Table 4: Mean Achievement Scores by Gender Under Blended Learning

Gender	N	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
Male	32	24..44	10.73	64.59	9.77	40.15
Female	31	20.00	7.38	59.39	8.92	39.39

As indicated in Table 4, both male and female students taught Biology using blended learning recorded similar academic improvements. Males had a slightly higher mean gain (40.15) than females (39.39), but the difference is minimal, suggesting that blended learning supports achievement across genders.

✓ There is no significant difference between the mean achievement scores of male and female students taught Biology using blended learning.

Table 5 ANCOVA Summary for Gender Differences in Blended Learning Group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1385.029[a]	2	692.515	9.476	.000
Intercept	24817.532	1	24817.532	339.586	.000
PreAch1	958.166	1	958.166	13.111	.001
BL	161.962	1	161.962	2.216	.142
Error	4384.907	60	73.082		
Total	248190.000	63			
Corrected Total	5769.937	62			

The ANCOVA results in Table 5show no statistically significant difference between male and female students in the blended learning group ($F(1, 60) = 2.216$, $p = .142$). Thus, blended learning provides a gender-inclusive environment for learning Biology, with no significant achievement gap between males and females.

✓ What difference exists between the mean achievement scores of male and female students taught Biology using guided inquiry?

Table 6: Mean Achievement Scores by Gender Under Guided Inquiry

Gender	N	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
Male	37	20.76	9.51	59.46	8.30	38.70
Female	37	22.14	9.48	56.65	11.80	34.51

Under the guided inquiry method, both male and female students showed substantial gains in Biology achievement as shown in Table 6. Although males recorded a slightly higher mean gain (38.70) than females (34.51), the difference is small, indicating general effectiveness of guided inquiry across genders.

✓ There is no significant difference between the mean achievement scores of male and female students taught Biology using guided inquiry.

Table 7: ANCOVA Summary for Gender Differences in Guided Inquiry Group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	604.767[a]	2	302.384	3.052	.054
Intercept	32506.352	1	32506.352	328.066	.000
PreAch3	458.605	1	458.605	4.628	.035
GI	185.730	1	185.730	1.874	.175
Error	7035.016	71	99.085		
Total	257040.000	74			
Corrected Total	7639.784	73			

The ANCOVA analysis for the guided inquiry group as shown in Table 7 showed no significant gender difference in students' achievement scores ($F(1, 71) = 1.874$, $p = .175$). Therefore, guided inquiry also supports equitable achievement among male and female students in Biology.

Discussion

The findings of this study revealed that students taught Biology using blended learning and guided inquiry strategies achieved significantly higher academic performance than those taught using the conventional lecture method. Among the three instructional approaches, the blended learning group recorded the highest mean achievement scores, followed closely by the guided inquiry group, while the lecture method group recorded the lowest. The significant difference between the achievement of students in the blended learning group and those in the guided inquiry group indicates that although both methods are learner-centered and effective, the integration of digital technology and flexible pacing in blended learning gives it a comparative edge. Students in the blended learning environment likely benefitted from multimodal content delivery, access to interactive simulations, and the opportunity to learn asynchronously at their own pace—features that enhance engagement and conceptual understanding. This aligns with the findings of Ibrahim and Musa (2022), who posited that blended learning offers enriched learning experiences that support deeper comprehension. Similarly, Abdullahi and Okonkwo (2023) emphasized that the autonomy and multimedia access in blended learning environments foster critical thinking and academic achievement.

The guided inquiry approach also significantly outperformed the lecture method, reinforcing its effectiveness in promoting active learning and critical reasoning. Guided inquiry empowers students to ask questions, engage in experimentation, and draw conclusions, all of which promote ownership of learning and long-term retention of knowledge. However, its relatively lower effectiveness compared to blended learning may be attributed to limited access to digital tools and the constraints of large class sizes or insufficient teacher support in practical implementation. This result supports the findings of Chukwu and Afolabi (2021), who reported that guided inquiry fosters scientific reasoning and achievement, though its effectiveness depends heavily on teacher facilitation. Likewise, Okoh and Nwanne (2024) found that guided inquiry enhances science learning but highlighted the need for structured support and resources to maximize its benefits.

Furthermore, the study found no significant difference in the academic achievement of male and female students taught Biology using blended learning. Though males had a slightly higher mean gain, the difference was not statistically significant, indicating that blended learning creates an inclusive environment that accommodates diverse learning preferences regardless of gender. This supports the assertion by Okoye and Oloyede (2023) that technology-integrated classrooms minimize gender-based performance gaps by promoting equal access to learning materials. Chidiebere and Adeyemi (2021) also

reported that both male and female students benefit equitably in digitally enriched environments when given equal opportunities for engagement.

Similarly, there was no statistically significant difference between male and female students taught using guided inquiry. Both genders demonstrated comparable levels of academic achievement, suggesting that guided inquiry promotes equitable participation through its emphasis on collaboration, experimentation, and reflection. The finding corroborates the work of Abubakar and Olaniyi (2022), who found that inquiry-based approaches provide equal opportunities for both genders to explore and internalize scientific concepts. Eze and Okolie (2023) similarly noted that guided inquiry fosters inclusive learning when teachers deliberately involve all students in group tasks and problem-solving activities.

Conclusion

The study concluded that teaching methods significantly influence students' academic achievement in Biology. Blended learning emerged as the most effective instructional strategy, followed by guided inquiry, while the traditional lecture method was the least effective. The superior performance of students exposed to blended learning and guided inquiry approaches demonstrates the importance of engaging, interactive, and learner-centered strategies in improving Biology achievement. Furthermore, while male and female students both benefited from blended learning and guided inquiry, the study found no statistically significant gender-based differences in achievement. This suggests that these modern teaching methods are equitable and inclusive across genders. However, the significant difference in achievement between students taught with blended learning and those taught with guided inquiry underscores the added value of integrating digital tools in Biology instruction. If schools continue to rely on conventional lecture methods, students may remain disengaged and underperform, which will, in turn, limit their readiness for science-based careers and higher education.

Recommendations

Based on the findings, the following are recommended:

1. Biology teachers should adopt blended learning strategies in their instructional delivery to enhance students' understanding and retention of biological concepts.
2. Guided inquiry should be incorporated more systematically into the Biology curriculum. Teachers should be trained to facilitate student-led investigations and promote scientific thinking.
3. Education stakeholders, including policymakers and school administrators, should invest in digital infrastructure in secondary schools to support the effective implementation of blended learning approaches.
4. Regular professional development workshops should be organized to build teachers' capacity in designing and implementing both blended and inquiry-based lessons effectively.

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