



Effects of Virtual and Guided Discovery Instructional Strategies on ... Dangana, B. M., Et. al. (2026)

Effects of Virtual and Guided Discovery Instructional Strategies On Academic Achievement in Biology Concepts among Secondary School Students in Adamawa State, Nigeria

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Abstract

This study examined the effects of virtual learning and discovery teaching methods on senior secondary school biology students' academic achievement in Adamawa state, Nigeria. Two research questions were raised and three null hypotheses were formulated and tested at 0.05 level of significance guided the study. The study adopted quasi-experimental design, with a pretest, posttest, nonrandomized non-equivalent, control group, design. The population of the study was 48,760 SSII biology students across five education zones of Adamawa State. A sample of 287 SS II students. biology students from three intact classes were purposively selected for the study. The instruments for data collection were Biology Achievement Test (BAT). The BAT scores were subjected to K-R 21 to determine the reliability of the instrument The reliability index of 0.82 was obtained. Data were analyzed using mean and standard deviation to answer the research questions, while ANCOVA were used to test the hypotheses. The findings of the study revealed that: There is significant difference between the mean achievement scores of students taught with virtual leaning approach, guided discovery approach and lecture method in senior secondary school in Adamawa state ($p=0.000$). There is significant difference between the mean achievement scores of male and female students' when taught Biology using virtual leaning approach in senior secondary school in Adamawa state ($p=0.000$). There is no significant difference between the mean achievement scores of male and female students' when taught Biology using guided discovery approach in senior secondary school in Adamawa state ($p=0.103$). The study recommended that: school administrators should encourage biology teachers to use teacher-students based activities such as guided discovery and virtual learning strategies during teaching and learning of biology content.

Keywords: Virtual learning, Guided discovery, Gender, Students' Academic Achievement, Biology



Introduction

Poor students' academic achievement in Biology has become a persistent concern in educational systems in Nigeria, especially in the North East, at the senior secondary school level. Studies have reported that many students perform below expectations in Biology in North East, Nigeria due to the insecurity, bandits' disturbances and Boko Haram insurgency, abstract nature of biological concepts, the breadth of the curriculum, and inadequate opportunities for inquiry-based learning (Nzewi & Oludipe, 2020; Mohammed, Abdullahi & Abubakar, 2025). In both developed and developing countries, students often struggle with understanding processes such as genetics, cell division, and ecological relationships. These difficulties are frequently linked to instructional strategies that emphasize memorization rather than conceptual understanding. Furthermore, global educational reports indicate that limited integration of technology and innovative teaching strategies contributes to students' declining interest and achievement in science subjects. In developing nations, these problems are intensified by insufficient learning resources, large class sizes, and limited teacher professional development. This challenge has drawn attention to the need for instructional reforms in science education with emphasis on Biology education. Biology, being foundational to life sciences, has been affected by these challenges. Therefore, improving students' academic achievement in Biology remains a global educational priority. At the national level, Nigeria has continued to experience poor academic achievement in Biology among senior secondary school students. Examination reports from WASSCE and NECO over the years indicate fluctuating but generally low pass rates in Biology. Researchers have attributed this poor Achievement to factors such as ineffective teaching methods, inadequate laboratory facilities, insufficient instructional materials, and low student engagement (Akinso & Obinna, 2020; Mohammed, Abdullahi & Abubakar, 2025). Many Nigerian classrooms still rely heavily on traditional teacher-centered approaches that limit student participation. Additionally, challenges such as overcrowded classrooms and insufficient exposure to practical work further weaken students' understanding of biological concepts. At the regional level, particularly in Adamawa State, these challenges are compounded by infrastructural deficits and limited access to digital learning tools. Consequently, poor academic achievement in Biology persists at the national and regional levels, underscoring the need for context-specific pedagogical interventions.

Biology is a natural science that deals with the study of living organisms, their structure, functions, development, evolution, and interactions with the environment. Biology also helps students understand issues related to health, environment, and sustainable development (FME, 2009). Despite its importance, many students perceive Biology as difficult and abstract. Biology concepts require visualization, experimentation, and inquiry for effective understanding. When these elements are absent, students struggle to grasp key ideas. Thus, effective Biology instruction must involve teaching methods that promote active engagement and conceptual clarity. Contemporary educational research, however, emphasizes learner-centered approaches that encourage inquiry and participation (Linus, Okwujiako, Abubakar & Mohammed, 2025; Ekpo & Nwagwu, 2020). Effective teaching methods should accommodate diverse learning styles and promote critical thinking. In Biology, instructional methods must support observation, experimentation, and problem-solving. Therefore, the choice of teaching strategy is crucial in determining learning outcomes. Research has shown that excessive reliance on lecture-based instruction leads to superficial learning and poor retention. Students taught primarily through lectures often struggle to apply concepts to real-life situations. As a result, the lecture method has been linked to poor academic achievement in Biology. This has led to calls for alternative instructional approaches.



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Virtual learning has emerged as an innovative instructional approach made possible by advancements in Information and Communication Technology. Virtual learning involves the use of digital platforms, online resources, and virtual classrooms to facilitate teaching and learning beyond physical classroom boundaries. It allows students to access learning materials anytime and anywhere. In Biology, virtual learning enables visualization of complex processes that are difficult to demonstrate in traditional classrooms. The approach also supports collaboration through online discussions and group activities. Its potential to enhance science education has attracted considerable research interest. Students exposed to virtual learning environments perform better academically than those taught solely through traditional methods (Estelami, 2018). Virtual learning promotes self-paced learning, which allows students to revisit difficult concepts. Studies in Biology education have shown that virtual simulations improve students' understanding of abstract topics such as genetics and cell division (Huang & Liu, 2020). Virtual laboratories provide opportunities for experimentation without physical constraints. Ibrahim (2017) reported that improved retention and conceptual understanding among students using virtual learning platforms. These findings suggest that virtual learning can address many challenges associated with Biology instruction when use appropriately. Similarly, Guided discovery teaching is a learner-centered instructional approach grounded in constructivist learning theory. It involves the teacher designing activities that guide students toward discovering concepts independently. Rather than presenting information directly, the teacher facilitates learning through questioning and structured tasks (Anderson, 2020). Students actively engage in exploration, observation, and reasoning. This approach encourages curiosity and critical thinking among learners. The teacher provides scaffolding to support students' learning process. Studies have shown that students taught using guided discovery outperform those taught through lecture methods in science subjects (Akinbobola & Afolabi, 2019). This implies that biology students exposed to guided discovery demonstrate better understanding of concepts to new situations and improved problem-solving skills. Ebukeye (2021) indicate that guided discovery fosters long-term retention of knowledge. This approach increases students' motivation and interest in learning of biology through scientific reasoning and analytical skills which may lead to academic improvement in both male and female. In Nigeria, gender issues continue to influence educational outcomes. Understanding gender dynamics is therefore essential in Biology education research. Empirical studies on gender and students' academic achievement in Biology have produced mixed findings. Some studies report that male students outperform females in science subjects, while others find no significant difference when learning conditions are equal (Nzewi & Oludipe, 2020). This implies that when effective teaching methods are used, gender differences in achievement diminish. Despite extensive research on Biology education and academic achievement, significant gaps remain. Therefore, this study investigates the effects of virtual learning and guided discovery on students' academic achievement in Biology.

Statement of the Problem

Over time there is a massive poor achievement of secondary school students in Biology when compare with number of students' enrolment. The problem of poor students' academic achievement in biology is link to the use of ineffective teaching strategies used in teaching biology concepts. Available statistics show that, the national average hovers around 32 percent. In support of the above assertion noted that it was only 48.88% of candidates who sat for June/July 2024 West African Senior School Certificate Examination (WASSCE) credited biology. In specific biology, (2024) 1,156,561 students sat for the examination with only 3,356 representing 0.28% obtaining distinction. Similarly, in the year (2023) only 24.86% got credit while 60.27% got pass. Also in the year 2022, 7.48% failed while about 4.27% were involved in malpractice. By implication, only 25.14% (distinction and credit



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percentage) were qualified for admission into universities, colleges and polytechnics. The students' poor Achievement in Biology may be attributed to the abstract concepts Such as in nervous system, excretory system, respiratory system, blood circulatory system, ecology, digestive system, tissue and supporting systems in animals among others (Singer, 2015; Mohammed, Abdullahi & Abubakar, 2025). Thus, the problem of the study posed: whether virtual learning strategy and guided discovery teaching method may improve students' achievement in Biology.

Purpose of the Study

The purpose of this study is to determine the effects of virtual learning and discovery teaching methods on senior secondary school biology students' academic achievement in Adamawa state, Nigeria. Specifically, the study sought to determine the: -

1. Effects of virtual learning, guided discovery teaching approaches and lecture method on senior secondary school biology students' academic achievement in Adamawa state, Nigeria.
2. Effect of virtual learning approaches on male and female Senior Secondary School Biology students' academic achievement in Adamawa state, Nigeria
3. Effect of guided discovery teaching approaches on male and female Senior Secondary School Biology students' academic achievement in Adamawa state, Nigeria.

Research Questions

The following research questions were raised to guide the study:

1. What are the pretest and posttest mean achievement scores of biology students when taught biology using virtual learning, guided discovery teaching approaches and those taught using lecture method?
2. What are the pretest and posttest mean achievement scores of male and female biology students when taught biology using virtual learning strategy and guided discovery teaching methods?

Hypotheses

The following null hypotheses were formulated to guide the study:

- H₀₁: There is no significant difference between the mean pretest, posttest achievement scores of students taught Biology Concepts using virtual leaning approach, guided discovery approach among senior secondary schools in Adamawa state.
- H₀₂: There is no significant difference between the achievement scores of male and female students taught Biology concepts using virtual leaning strategy among senior secondary schools in Adamawa state.
- H₀₃: There is no significant difference between the achievement scores of male and female students' taught biology concepts using guided discovery teaching method among senior secondary schools in Adamawa state.

Methodology

This study employed quasi-experimental pretest, posttest, nonrandomized, non-equivalent control group design. The area of the study is Adamawa State Nigeria. The population of the study consist of 48,760 SSII students offering Biology in all public Senior Secondary Schools of Adamawa state. Sample of this study was 287 SS II students (137 males and 150 females) offering Biology in three co-educational senior secondary schools in Adamawa State. Purposive sampling techniques were used to select three senior secondary schools from the two education zones. The sampled students in each intact class were randomly assigned to experimental groups I, II and control group by ballots. The first picked paper was assigned as experimental group I (virtual learning). The second two picked paper was assigned as experimental group II (guided discovery). The third picked paper were assigned as control group. The selected biology teachers in each school followed the school time table as



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provided by the school management. The instrument used was Biology Achievement Test (BAT) which contains 50 items. The instrument consists of 50 multiple choice objective tests items with four options (A-D) with one key and three distracters developed to assess the academic achievement of the groups. The instrument was adapted from West African examination past biology question papers from 2018-2024. The instrument was delimited to Circulatory System, Respiratory system and Excretory System. The Biology Achievement Test (BAT) was subjected to face and content validity. To determine the reliability of the instrument, the instrument was subjected to trial testing on 40 SS II students in Staff Secondary School Federal Polytechnic Mubi, Yola Campus which are not part of the study. The reliability of the Biology Achievement Test (BAT) was determined using Kuder-Richardson Formula (K-R21) and a reliability index of 0.82 was obtained. The first week pre-test was administered to both the experimental I II and control groups. The experimental groups 1 taught using Virtual Learning Strategy and experimental group were taught using Guided Discovery teaching method and the control group were taught using lecture method After the treatment, post-test were administered to the experimental groups which lasted for one week. The data collected were analyzed using mean and standard deviation to answer the 2 research questions. For testing the 3 null hypotheses, the Analysis of Covariance (ANCOVA) was tested at a 0.05 level of significance. If $P < 0.05$ level of significance, reject the null hypothesis and if the $p > 0.05$ level of significance do not reject the hypothesis.

Presentation of Results

Research Question 1:

What are the pretest and posttest mean achievement scores of Students taught Biology concepts using Virtual Learning, Guided Discovery Teaching Approaches and those taught using lecture method?

Table 1: Mean and Standard Deviation of Pre – Test and Post Test Scores of Students taught Biology using Virtual Learning, Guided Discovery Teaching Approaches and those taught using Lecture Method

Group	n	Pre – test		Post – test		Mean Gain
		M	S. D	M	S. D	
Virtual Learning	94	11.39	6.59	24.99	8.81	13.90
Guided Discovery	96	11.59	7.29	32.61	8.92	21.02
Lecture Method	97	9.02	5.04	19.63	6.91	10.61

The results in Table 1 shows the differences in students’ achievement scores across the three instructional methods. At the pretest stage, students in the virtual learning group (Mean = 11.39) and guided discovery group (Mean = 11.59) started with similar baseline Achievement levels, while those in the lecture group had a lower mean score of 9.02. After the instructional interventions, all groups improved, but the extent of improvement varied widely. Students taught with guided discovery recorded the highest posttest mean score (Mean = 32.61), followed by the virtual learning group (Mean = 24.99), while the lecture method group had the lowest posttest mean (Mean = 19.63). A comparison of mean gains further highlights the effectiveness of the instructional strategies. Guided discovery produced the largest mean gain of 21.02, indicating a strong positive effect on students’ biology achievement. Virtual learning also produced a substantial improvement with a mean gain of 13.90. In contrast, the lecture method resulted in the smallest gain of 10.61, suggesting that although students improved, the traditional approach was less effective than both virtual and guided discovery methods.



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Research Question 2:

What are the pretest and posttest mean achievement scores of male and female students when taught Biology using virtual Learning, guided discovery and lecture methods?

Table 2: Mean and Standard Deviation of Pre – Test and Post Test Scores of Male and Female Students taught Biology using Virtual Learning, Guided Discovery Teaching Approaches and those taught using Lecture Method

Group	Gender	N	Pre – test		Post – test		Mean difference
			M	S. D	M	S. D	
Virtual Learning	Male	45	8.22	4.71	19.89	6.28	9.78
	Female	49	14.31	6.76	29.67	8.21	
Guided Discovery	Male	42	12.05	7.95	34.36	7.92	3.10
	Female	54	11.24	6.80	31.26	9.48	
Lecture Method	Male	50	8.84	4.94	20.04	6.18	0.85
	Female	47	9.21	5.19	19.19	7.66	

Table 2 examines the Achievement of male and female students within each teaching approach. In the virtual learning group, female students outperformed male students at both the pretest and posttest stages. Females had a higher posttest mean score (29.67) compared to males (19.89), resulting in a mean difference of 9.78 in favor of female students. This suggests that female learners responded more positively to virtual learning in biology. For the guided discovery group, the trend differs. Male students recorded a higher posttest mean score (34.36) than females (31.26), producing a mean advantage of 3.10 for males. This indicates that male students benefited more from the guided discovery approach. Meanwhile, in the lecture group, the Achievement difference between genders was minimal. Males had a slightly higher posttest mean score (20.04) compared to females (19.19), giving a small mean difference of 0.85 in favor of males, suggesting that the lecture method affected both genders almost equally.

Hypotheses Testing

H₀₁: There is no significant difference between the mean achievement scores of students taught biology concepts using virtual leaning approach, guided discovery approach and lecture method among senior secondary school in Adamawa state.

Table 3: Summary of ANCOVA of Difference between the Mean Achievement Scores of Students when taught Biology using Virtual Leaning Strategy, Guided Discovery and Lecture Method Approach in Senior Secondary School in Adamawa State

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13387.560 ^a	3	4462.520	88.953	.000	.485
Intercept	25893.039	1	25893.039	516.138	.000	.646
Pretest	5175.127	1	5175.127	103.158	.000	.267
Teaching methods	6195.791	2	3097.896	61.752	.000	.304
Error	14197.241	283	50.167			
Total	217562.000	287				
Corrected Total	27584.801	286				

a. R Squared = .485 (Adjusted R Squared = .480)

The results of the ANCOVA in Table 3 show that the teaching method had a statistically significant effect on students’ achievement in biology after controlling for pretest scores. The main effect of teaching method yielded an F-value of 61.752 with a significance value of 0.000, which is less than



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the 0.05 alpha level. This indicates that the differences in students' posttest achievement scores across the three instructional strategies are statistically significant. Therefore, the null hypothesis (H_{01}) is rejected.

H_{02} : There is no significant difference between the achievement scores of male and female student taught Biology concepts using virtual learning approach among senior secondary schools in Adamawa state.

Table 4: Summary of ANCOVA of Difference between the Mean Achievement Scores of Male and Female Student when taught Biology using Virtual Learning Approach in Senior Secondary School in Adamawa State

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2780.510 ^a	2	1390.255	28.504	.000	.385
Intercept	8015.263	1	8015.263	164.333	.000	.644
Pre-test	534.741	1	534.741	10.964	.001	.108
Gender	977.503	1	977.503	20.041	.000	.180
Error	4438.479	91	48.774			
Total	65919.000	94				
Corrected Total	7218.989	93				

a. R Squared = .385 (Adjusted R Squared = .372)

The ANCOVA results in Table 4 show that gender has a statistically significant effect on students' posttest achievement scores after controlling for pretest differences. The gender variable produced an F-value of 20.041 with a significance level of 0.000, which is below the 0.05 threshold. This means male and female students performed differently under the virtual learning approach. Therefore, H_{02} is rejected.

H_{03} : There is no significant difference between the mean achievement scores of male and female student taught Biology concepts using guided discovery approach among senior secondary schools in Adamawa state.

Table 5: Summary of ANCOVA of Difference between the Mean Achievement Scores of Male and Female Student when taught Biology using Guided Discovery Approach in Senior Secondary School in Adamawa State

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2065.915 ^a	2	1032.958	17.464	.000	.273
Intercept	17714.546	1	17714.546	299.492	.000	.763
Pret-test	1839.189	1	1839.189	31.094	.000	.251
Gender	160.489	1	160.489	2.713	.103	.028
Error	5500.824	93	59.149			
Total	109683.000	96				
Corrected Total	7566.740	95				

a. R Squared = .273 (Adjusted R Squared = .257)

The ANCOVA results in Table 5 reveal that gender did not significantly affect achievement when guided discovery was used. The gender variable had an F-value of 2.713 with a significance level of 0.103, which is greater than the 0.05 alpha level. Since this result is not statistically significant, H_{03} is retained. This result indicates that male and female students achieved comparable Achievement when taught with guided discovery. The partial eta squared value (0.028) is very small, suggesting a minimal effect of gender on achievement under this method. Guided discovery, therefore, appears to be a gender-fair instructional approach, benefiting both male and female students similarly.



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Findings of the Study

1. There is significant difference between the mean achievement scores of students taught using virtual learning approach, guided discovery approach and lecture method among senior secondary schools in Adamawa state.
2. There is significant difference between the mean achievement scores of male and female students taught Biology concepts using virtual learning approach among senior secondary schools in Adamawa state.
3. There is no significant difference between the mean achievement scores of male and female students taught Biology concepts using guided discovery approach among senior secondary schools in Adamawa state.

Discussion of Findings

There is significant difference between the mean achievement scores of students taught using virtual learning approach, guided discovery approach and lecture method in senior secondary school in Adamawa state. This finding agrees with Tope and Samuel (2022) whose results showed a significant difference between the mean pre- and post-test achievement and retention capacity of students who were receiving science instruction through Virtual learning strategy and Guided Discovery Teaching Method. Similarly, Mohammed, Adenike and Johnson (2023) revealed that the Achievement of students taught through Virtual learning strategy and Guided Discovery Teaching Method was statistically significantly better than conventional learning. Nwankwo and Uche (2024) findings of the study showed significance effect of Virtual learning strategy and Guided Discovery Teaching Method on Students' interest in Biology. This implies that Virtual learning strategy and Guided Discovery Teaching Method is capable of enhancing interest and achievement in Biology. On the contrary, Okafor and Omoifo (2023) found among others that there is no significant difference in achievement between students taught Biology with Virtual learning strategy and Guided Discovery Teaching Method and traditional method.

There is significant difference between achievement scores of male and female students taught Biology concepts using virtual learning approach among senior secondary schools in Adamawa state. This finding agrees with Gambari (2017) show that there was significant difference in the mean achievement scores of male and female students taught using Chemistry using Virtual Laboratory in Individualized Setting. Subrata and Palash (2017) revealed that there is a significant difference between mean test score of control and virtual learning group between male and female. On the contrary, Gambari (2017) revealed that there was no significant difference in the mean achievement scores of male and female students taught chemistry using virtual laboratory in collaborative learning setting.

There is no significant difference between achievement scores of male and female students taught Biology concepts using guided discovery approach among senior secondary schools in Adamawa state. This study agrees with Abari and Ikyule (2021) findings also revealed no significant difference in mean achievement scores of male and female students taught Mathematics using Guided discovery approach. In the same vein, Dajal and Adamu (2019) there was no significant difference between the mean achievement scores of male and female students in the guided discovery group. On the contrary, Salihu (2015) found that male students taught ecology with guided discovery performed better than their female counterparts. Similarly, Akanbi, and Kolawole, (2014) revealed that guided-discovery had significant main effect of male and female students' achievement score.



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Conclusion

It was concluded that virtual learning approach, guided discovery approach and lecture method improve students' academic achievement at different levels. Students taught with guided discovery performed significantly better than those taught with virtual learning while students taught through virtual learning outperformed those taught via the lecture method. Guided discovery and virtual learning strategies are gender friendly.

Recommendations

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

1. School administrators should encourage biology teachers to use teacher-students based activities such as guided discovery and virtual learning strategies during teaching and learning of biology content.
2. School administrators should encourage biology teachers by organizing seminars and workshops on virtual learning strategies to teach biology as it supports gender inclusion.
3. Government should show commitment in improving students' participation such as guided discovery learning strategy during biology teaching because is gender friendly.

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