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Original Research Article

Effects of Inquiry-Based Teaching and Lecture Methods on Biology Students' Achievement in Delta Central Senatorial District

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Abstract

The study was carried out to investigate the effect of inquiry-based teaching and the lecture method on students' achievement in Biology in senior secondary schools in the Delta Central Senatorial District. Four (4) research questions were raised, and four (4) hypotheses were formulated and tested at a 0.05 alpha level of significance. The study adopted pre-test and post-test non-equivalent planned variation as a quasi-experimental design. The study sample consisted of 325 biology students, selected using stratified and simple random sampling procedures from schools. The Biology Achievement Test (BAT) was the instrument used in this study and validated by three Experts. Reliability coefficients of 0.76 was established for BAT. The data collected were analyzed using descriptive statistics and independent sample t-test and ANCOVA. The findings of the study are: (i) there is a significant difference in mean achievement and interest scores between students taught with inquiry-based teaching and lecture method, (ii) there is no significant difference between mean scores of male and female students exposed to inquiry-based teaching method on achievement amongst others. It was recommended that inquiry-based instruction be encouraged among Biology teachers to raise students' dwindling interest in the subject and improve students' achievement.

Keywords: Inquiry-based teaching, Lecture, Instructional strategy, Students, Achievement, Biology.

INTRODUCTION

Biology is the scientific study of life. Its study holds a pivotal position in science and technology because of its nature and the importance it places on life. Biology is the branch of natural science that is concerned with the study of living things, including their taxonomy, structure, and function (Obigbor & Ajaja, 2023). Biology teaching and learning cover many areas, such as cell biology, botany, zoology, genetics, ecology, biochemistry, microbiology, etc. Biology helps students to acquire scientific knowledge and skills to build their lives and the nation. The Federal Ministry of Education (FME, 2018) recommends that at the secondary school level, the goal of the biology curriculum is to help students develop the laboratory and field skills necessary to study the subject, as well as the content knowledge and analytical reasoning skills necessary to apply that knowledge to practical issues of life and improve the students' achievement. Biology learning equips learners with knowledge and skills that help them to face challenges in society, especially those related to common diseases, pollution, and genetics. Furthermore, Biology leads to self-understanding of how the body works (Kareem, 2018), hence it deserves due consideration in school curricula as well as an emphasis on the teaching-learning continuum. Therefore, schools must adopt effective methods to teach this subject so that planned objectives can be achieved and the achievements of the students can be improved.

Despite the importance of Biology as a subject, students' achievement in external examinations has remained unsatisfactory. It has been observed that Biology achievement in the past years in terms of success rate has been below 50%, which is not that encouraging (WAEC, 2023). The poor achievement of students in science, particularly in Biology, in external examinations has also been attributed to poor teaching strategies and learning (WAEC Chief Examiner's Report, 2023). Therefore, it is imperative that new and innovative strategies are used by teachers and students for effective teaching and learning. Thus, inquiry-based teaching has

been one of the specified teaching strategies for the 21st century.

Inquiry is a term often used in science classrooms to define the scientific process of search and construction of knowledge (Guisti, 2008). The inquiry method, or inquiry-based teaching, is an approach that assists students in developing knowledge, experience, and understanding through research. It equips students with different skills that include problem-solving, creativity, critical thinking, and science process (Chukwuemeka, 2015). Ajaja and Eravwoke (2010) opined that making Biology learning effective is related to study skills or behavior. They also stated that the way students learn makes them better if they are allowed to actively participate in the teaching-learning process. Inquiry-based teaching is a form of active teaching in which one starts by asking a series of questions, problems, or scenarios. Unlike the lecture teaching methods, this is generally student-centered. The inquirer researches issues and questions to acquire knowledge and find solutions to problems. The inquiry-based teaching increases students' engagement in teaching and learning, as well as helps them develop science process skills to carry out an inquiry (Ali, 2014). In the process, one can also develop the skills and strategies needed to implement inquiry-based teaching. Inquiry-based teaching is a student-centered approach in which the teacher guides students through the posing of questions, the design of methods, and the interpretation of data. Inquiry-based teaching facilitates the teaching and learning process, which helps both teachers and students to be actively involved in the process. It is a strategy where learners actively explore topics through curiosity and investigation, which includes orientation/observation, questioning, investigating, analyzing and interpreting findings, concluding, and discussing/sharing. The stages of inquiry-based teaching include:

Orientation/observation is the starting point where one becomes familiar with the topic or problem. It involves observing, gathering initial information, and identifying what sparks your interest or needs exploration.

Questioning stage involves the formulation of questions based on observations. These questions guide the inquiry, helping students focus on what they want to learn or solve.

Investigation stage involves researching and collecting data or evidence to answer questions raised. This is through experiments, reading, or sorting out resources.

The analysis and interpretation stage involves examining the information gathered, looking for patterns or insights, and making sense of it in relation to the intended questions raised.

The conclusion stage is a stage where conclusions based on analysis are drawn. Students come to a reasoned answer or solution, summarizing what they have learned or discovered, and the discussion/sharing stage is where students share their findings, discuss the implications, and possibly get feedback or new perspectives to refine their understanding.

Through inquiry, students get actively involved in teaching/learning and discover knowledge by themselves to support their investigation (Ogundola, 2014). Science educators, Aminu, (2010) and Onyenechere, (2014) advocated for inquiry-oriented approaches because it (i) engage students' interest in science, (ii) provide opportunities for students to use appropriate laboratory technique (iii) require students to solve problems using logic and evidence, (iv) encourage students to conduct further study to develop more elaborate explanations, and (v) emphasize the importance of writing scientific explanations based on evidence. Sandoval & Reiser (2004) pointed out that in order to build inquiry-based teaching, the lesson must be project-based and filled with activities that will encourage students' participation. They must experience the process of knowing and be able to give their own justification of knowledge and interpretation of Biology concepts.

On the other hand, the lecture method is a common teaching strategy in which an instructor shares information with a group of students through a structured, spoken presentation. The lecture method is a traditional teaching approach where an instructor delivers information to students through oral presentation. This method has been widely used in secondary schools for centuries and is still a popular choice among educators today. It's among the oldest and most conventional approaches to passing down knowledge. It is used frequently in settings like classrooms, universities, or seminars (Abamba, 2012). It allows an instructor to efficiently deliver a large amount of information to many learners at once. The advantages of the lecture method are that it saves time and energy; it offers easy coverage of the syllabus and faster dissemination of scientific information and facts; it allows easy handling of large classes without much stress; and it helps students, as their efforts in searching for facts in books are saved since the teachers present the information directly. The teacher has full control of what the students should learn or know. Additionally, it fosters a shared learning experience among students. It is believed that when effective strategies are used, students will develop an interest in the subject.

Achievement describes the outcome that shows the degree to which students have attained their learning goals. Arora (2016) stressed that achievement is the degree or level of success or proficiency someone attains in some academic work. Examinations or ongoing evaluations are frequently used to measure educational

success or achievement. It enables students to determine the relative position or rank with respect to their performance (Etuk *et al.,*2011). Campbell in Aniaku (2012) referred to achievement as the result of any teaching and learning process that reflects the level of attainment of educational goals within an institution. Aniaku (2012) described achievement as an individual`s grades generated from examinations or continuous assessments, which can be used to determine intellectual skills. Ibrahim (2015) defines academic achievement as behaviours that ensure that goals are continuously met in an effective and efficient manner. It is imperative to state that students' interest positively influences academic achievement, while gender may affect both interest and achievement by shaping students' learning experiences and outcomes.

Sex is the categorization of individuals based on their biological trait of being a male or female. Educational differences between male and female students are a major issue. Some research indicated that male students outperformed their female counterparts, while others found the exact opposite. Hence, there is little agreement on the conclusions of studies on the effect of gender on academic attainment among students. Abamba, (2023) and Omovie (2023) study showed no significant difference in the achievement of male and female students instructed using the inquiry and the lecture methods. Nnamani and Oyibe (2016) noted that the mean achievement score of female secondary school students was significantly higher than the mean achievement scores of male students. Akintade's (2017) study showed that there was no interaction effect related to treatment, gender, and students' subject area in the post-test scores. The study of Umoru and Adekunle (2019) showed that the interaction effects of gender and teaching methods were not significant on students' achievement and retention in Basic Science. This means that gender and teaching method did not significantly interact in the students' achievement.

It is against this backdrop that this study determined the effects of inquiry-based teaching and the lecture method on biology students' achievement and interest, considering the fact that both strategies differ in the mode of their application.

Statement of the Problem

Despite the importance of Biology teaching and learning in secondary schools, students' achievement in Biology has been poor over the years. There has been a high rate of poor achievement of Biology students in both internal and external examinations over the years. This poor achievement in the subject can be linked to the teachers' use of ineffective methods and students' lack of interest in Biology learning. A critical look at students' achievement in Biology in the Secondary School Certificate Examination over the years shows consistently low performance. Yearly reports in public examination indicated low academic achievement of students in Biology. Statistics from the West African Examinations Council (WAEC, 2017, 2018, 2019, 2020, 2025) show that students' achievement in Biology was unsatisfactory and that students failed to obtain more grades at credit level and above. It is observed that part of the reasons for the failure of male and female students in examinations can be attributed to many factors, which include the methods of teaching adopted by teachers for teaching Biology. Therefore, the problem of this study is, what is the effects of inquiry-based teaching and lecture methods on students' achievement in Delta Central Senatorial District?

Research Questions

The following questions were raised to guide the study:

1. What is the effects in mean achievement scores between students taught with inquiry-based teaching and lecture methods in Delta Central Senatorial District?
2. What is the difference in mean achievement scores between students taught with inquiry-based teaching and lecture method?
3. What is the difference between the mean achievement scores of male and female students exposed to inquiry-based teaching in Delta Central Senatorial District?
4. What is the interaction effect between methods and sex on students' achievement?

Hypotheses

H_{01}: There is no significant effects of inquiry-based teaching and lecture methods on Biology students' achievement.

H_{02}: There is no significant difference in mean achievement scores between students taught with inquiry-based teaching and lecture methods in Delta Central Senatorial District.

H_{03}: There is no significant difference between the mean achievement scores of male and female students exposed to inquiry-based teaching in Delta Central Senatorial District.

H_{04}: There is no significant interaction effect between methods and sex on students' achievement.

METHODOLOGY

The design employed in this is the quasi-experimental design, which involves pre-test and post-test and planned variation. The population for the study is thirteen thousand, eight hundred and forty-five (13,845) SS II Biology students. The sample size of the study is 325 senior secondary two (SS2) Biology students. The sample was drawn using a multistage sampling technique. The instrument used for data collection, which is duly face and content validated is the Biology Achievement Test (BAT)with reliability coefficients of 0.72 determined using Kuder-Richardson Formula – 21 (K-R-21). Before the actual treatment, the two Biology teachers who served as research assistants in the study were properly trained on how to use the inquiry-based teaching method. This training lasted for 4

days, 3 hours each day. The first day was spent discussing the theories, origins, and characteristics of the inquiry-based learning method. On the second day, the instructors were trained using the training manuals on the inquiry-based learning method. The two instructors for the experimental group were trained by the researcher. The training manual specifically defined the steps and stages involved in using inquiry-based learning for teaching and the specific roles teachers and students play in each stage. On the third and fourth days, the teachers were made to practice the strategies, and the training came to a close when the researcher and the resource person were convinced that the biology teachers trained could accurately apply the strategy in teaching the topics to the selected schools for the study. The groups were pre-tested to establish equivalence and to ensure that any observed changes at post-test could be attributed to the treatment administered. Following the pre-test, the groups underwent the treatment, where one group was taught using inquiry-based learning instructional strategy and the other, lecture method. Post-tests were then conducted immediately after the treatment. Data collected were analyzed using mean, standard deviation for the research questions, while the hypotheses were tested at a 0.05 level of significance using t-test, and Analysis of Variance (ANOVA).

RESULTS

Research question 1: What is the effects of inquiry-based teaching and lecture methods on Biology students' achievement?

Table 1: Descriptive Statistics of Mean and Standard Deviation of Inquiry-based Teaching and Lecture Method on Biology Students Achievement

Teaching Methods	Tests	N	$\bar{X}$	$\bar{X}_{diff}$	SD
Inquiry-Based Teaching	Pretest	154	39.67		16.17
	Posttest	154	86.17	46.50	6.85
Lecture	Pretest	171	43.50		21.68
	Posttest	171	70.48	26.98	14.15

Table 1 shows a pretest mean achievement score of 39.67 with a standard deviation of 16.17 for students, and a posttest mean achievement score of 86.17 with a standard deviation of 6.85. The mean difference between the two tests is 46.5, in favour of the posttest taught with inquiry-based teaching. It is shown in same table that for lecture method, a pretest mean achievement score of 43.50 with a standard deviation of 21.68 for students, and a posttest mean achievement score of 70.48 with a standard deviation of 14.15. The mean difference between the two tests is 26.98, in favour of the posttest taught with lecture method. To determine whether the observed difference in Table1 is significant, hypothesis 1 was tested using a paired-samples t-test, and the results are presented in Table 2.

H_{01}: There is no significant effects of inquiry-based teaching and lecture methods on Biology students' achievement.

Table 2: Paired-Sampled t-test comparing Pretest and Posttest of Inquiry-based Teaching and Lecture Method on Biology Students Achievement

Teaching Methods	Tests	N	$\bar{X}$	$\bar{X}_{diff}$	SD	df	t	P-value	Decision
Inquiry-Based Teaching	Pretest	154	39.67	46.50	17.50	153	32.97	0.00	H_{01} (Significant)
	Posttest	154	86.17						
Lecture	Pretest	171	43.50	26.98	30.34	170	11.63	0.00	H_{01} (Significant
	Posttest	171	70.48						

The result of the study showed that the paired sampled t-test for inquiry-based teaching and lecture method. The result showed significant difference between the pretest and posttest scores with P-value (0.000) less than the critical value of 0.05. Also, there is a significant difference between the pretest and posttest scores of groups taught with lecture method with P-value (0.000) less than 0.05. Therefore, it can be concluded that both method of teaching significantly improved students' achievement in Biology.

Research question 2: What is the difference in mean achievement scores between students taught with inquiry-based teaching and lecture method?

Table 3: Descriptive Statistics of Mean and Standard Deviation of the difference in mean achievement scores between students taught with the inquiry-based teaching and the lecture method

Teaching Methods	N	$\bar{X}$	$\bar{X}_{diff}$	SD
Inquiry-Based Teaching	154	86.17	15.69	6.85
Lecture Method	171	70.48		14.15

Table 3 shows that the mean achievement score of 86.17 with a standard deviation of 6.85 for students taught with Inquiry-Based Teaching, while the mean achievement score is 70.48 with a standard deviation of 14.15. The mean difference between the two teaching methods is 15.69, in favor of students taught with inquiry-based teaching. Therefore, there is a difference in the achievement of students taught with the inquiry-based teaching and lecture method.

Hypothesis 2: There is no significant difference in mean achievement scores between students taught with inquiry-based teaching and the lecture method.

To determine the right statistics for hypothesis 2, the test of equivalence was calculated using the pretest score of both groups and the result is presented in table 4.

Table 4: The equivalence of the groups for t-test of the pretests across the groups on Biology Students Achievement

Groups	N	$\bar{X}$	SD	df	T	P-value	Decision
IBT	154	39.67	16.17	323	1.791	0.074	H_{01} (Significant)
LM	171	43.50	21.68				

From the t-test result, the P-value of 0.07 is greater than 0.05, which indicate a no significant difference at pretest, therefore, t-test becomes the appropriate statistics and the result is presented in Table 5.

Table 5: Independent sample t-test of Inquiry-based Teaching and Lecture Method on Biology Students' Achievement

Teaching Methods	N	$\bar{X}$	$\bar{X}_{diff}$	SD	Df	T	Sig. (2-tailed	Decision
Inquiry-Based Teaching	154	86.17	15.69	6.85	323	12.502	0.00	**H_{01} (Significant)**
Lecture Method	171	70.48		14.15				

Table 5 shows that the observed difference is significant because the Sig. value 0.00 is less than 0.05 alpha level (P<0.05) between the students taught with the inquiry-based teaching and lecture method. Therefore, hypothesis 2, which states that there is no significant difference in mean achievement scores between students taught with inquiry-based teaching and the lecture method, was rejected. This implies that there is a significant difference in mean achievement scores between students taught with the inquiry-based teaching and the lecture method.

Research question 3: What is the difference between the mean achievement scores of male and female students exposed to inquiry-based teaching?

Table 6: Descriptive Statistics of Mean and Standard Deviation of the difference between the mean achievement scores of male and female students exposed to inquiry-based teaching

Inquiry-based Teaching (Sex)	N	$\bar{X}$	$\bar{X}_{diff}$	SD
Male	67	86.20	0.07	7.18
Female	87	86.13		6.44

Table 6 indicates that male biology students instructed through inquiry-based teaching achieved a mean score of 86.20 with a standard deviation of 7.18, whereas female students achieved a mean score of 86.13 with a standard deviation of 6.44. The resulting mean difference of 0.07 favours male students in the inquiry-based teaching context. To determine if this observed difference is significant, Hypothesis 2 was tested using an independent sample t-test.

Hypothesis 3: There is no significant difference between the mean achievement scores of male and female students exposed to inquiry-based teaching.

Table 7: Independent sample t-test of mean achievement scores of male and female students exposed to inquiry-based teaching

Inquiry-based Teaching (Sex)	N	$\bar{X}$	$\bar{X}_{diff}$	SD	df	t	Sig. (2-tailed)	Decision
Male	67	86.20	0.61	7.18	152	12.502	0.765	**H_{02} (Not Significant)**
Female	87	86.13		6.44				

Table 7 shows that the observed difference is not significant because the Sig. The value 0.765 is greater than the 0.05 alpha level (P>0.05) between male and female students taught with inquiry-based teaching. Therefore, hypothesis 2, which states that there is no significant difference between the mean achievement scores of male and female students exposed to inquiry-based teaching, is accepted.

Research question 4: What is the interaction effect between methods and sex on students' achievement?

Table 8: Descriptive Statistics of Mean and Standard Deviation of interaction effect of method and sex on Biology students Achievement

Teaching Methods	Sex	N	$\bar{X}$	$\bar{X}_{diff}$	SD
Inquiry-Based Teaching	Male	154	86.17		6.85
	Female			46.50	
Lecture Method		171	70.48		14.15
		67	62.67	2.24	6.94
Inquiry-Based Teaching	Male	87	60.43		6.56
	Female	73	58.60		4.87
Lecture Method				3.24	
		98	59.84		4.95

Table 8 shows that at posttest mean achievement score of 86.17 with a standard deviation of 6.85. Also, at posttest mean achievement score of 70.48 with a standard deviation of 14.15. The mean difference between the two tests is 46.50, in favour of the posttest taught with inquiry-based teaching. Also, in Table 4.14 showed that a mean achievement score of 62.67 with standard deviation of 6.94 for male students while mean achievement score 60.43 with standard deviation of 6.56 for female students exposed to inquiry-based teaching with mean difference between both sexes is 2.24. The same table shows that a mean achievement score of 56.60 with standard deviation of 4.87 for male students while mean achievement score 59.84 with standard deviation of 4.95 for female students exposed to lecture method with mean difference between both sexes is 3.24.

To determine if this observed difference in table 8 is significant, hypothesis 4 was tested using ANCOVA and the result is presented in Table 9.

H_{04} : There is no significant interaction effect between methods and sex on students' achievement.

Table 9: ANCOVA Analysis showing the interaction effect between methods and sex on students' achievement

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	23880.037	5	477.005	40.866	.000
Intercept	92341.665	1	92341.665	790.122	.000
pretest	3667.313	1	3667.313	31.379	.000
Methods	17958.222	1	17958.222	153.660	.000
Sex	203.900	2	101.950	.872	.419
Methods*Sex	15.799	1	15.799	.135	.713
Error	37281.560	319	116.870		
Total	2034096.000	325			
Corrected Total	61161.588	324			

a. R Squared=.390 (Adjusted Square =.381)

Table 9 shows that the F (1,319) =0.135, p=0.713 which is not significant at 0.05 level of significance. Since the p-value of .713 is greater than 0.05 alpha level, the null hypothesis is accepted. This implies that there is no significant interaction effect between methods and sex on students' achievement.

DISCUSSION OF FINDINGS

The first finding in tables 1 and 2 indicate a significant effect of inquiry-based teaching and lecture methods on Biology students' achievement. This indicates that students in the posttest performed better than their pretest in both inquiry-based teaching and lecture method. Students who were exposed to inquiry-based teaching and lecture method have a better understanding of biology after exposure, because they have more knowledge and skills based on the treatment they received. Furthermore, Inquiry-based teaching and lecture method helps students to gain more knowledge during the teaching process. This is achieved because of series of tremendous and minds on activities that they were engaged in. These activities enabled get involved in solving problems associated with the concepts studied and also made them interact with themselves and the teachers. This act would have made them learn better their counterpart. These findings are consistent with the work of Anthonia & Ngozi (2022), who found that students who received treatment (posttest) were better than those without treatment (pretest); this supports the pattern seen in my results and affirms the value of IBT approaches. Similarly, Minner *et al.,* (2010) found that students who participated in IBT-based science instruction outperformed their peers on standardised tests, a finding that echoes the positive outcomes observed in my own study. By confirming and extending the results of previous research, the findings provide additional evidence of the effectiveness of inquiry-based

teaching and lecture method in improving student achievement.

Secondly, the finding of the study indicated that students taught using the inquiry-based teaching method scored significantly higher (M = 86.17, SD = 6.85) than those taught using the lecture method (M = 70.48, SD = 14.15), t = 15.69. The data collected and analyzed showed that students taught using inquiry-based teaching achieve a higher mean score than those taught using the lecture method. This is because inquiry-based teaching increases students' engagement in teaching and learning, helping them carry out hands-on and minds-on activities. Inquiry-based teaching facilitates the teaching and learning process, helping both teachers and students be actively involved and thereby improving students' achievement. Its usage allowed students to actively explore and investigate real-world problems and questions, rather than simply receiving information from a teacher. This finding aligns with Kessy and Irénée (2021), who found that students taught through inquiry-based teaching performed better than those taught through conventional methods. Also, Ali (2014) found that students who were taught through inquiry-based learning achieved higher scores than those taught with the lecture method.

The third finding of the study indicated that there is no significant difference in mean achievement scores between male and female students taught using inquiry-based teaching. This shows that the male and female students benefited equally when the strategy was used, hence a non-significant difference was found. This result is consistent with the findings of Kelubia *et al.,* (2023), who also reported no significant gender difference in achievement with inquiry-based teaching.

The fourth finding showed that there is no significant interaction effect between methods and sex on students' achievement. This finding shows that the increase in post-test score was solely due to the methods. This finding disagrees with that of Umoru and Adekunle (2019) found an interaction effects of gender and teaching methods was not significant on students' achievement to support this result.

CONCLUSION

In line with the findings of the study, the study concluded that both lecture method and inquiry-based teaching significantly improved the academic achievement of biology students. However, students taught with inquiry-based teaching achieved academically better than the lecture method. The study also established that when effectively implemented, the achievement of male and female students exposed to inquiry-based teaching will not differ significantly.

Recommendation

The following recommendations were made based on the study's analysis, findings, and conclusions.

1) The study recommended that secondary school educators incorporate IBT in teaching Biology.
2) The use of inquiry-based instruction should be encouraged among teachers of Biology to raise the level of the dwindling interest of students towards the study of Biology.
3) The use of inquiry-based instruction should be encouraged among teachers to improve students' acquisition of skills involved in its usage. Inquiry-based instruction should also be encouraged to promote learning in Biology among both male and female students.

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