International Journal of Science Education and Environmental Research

Submitted: 12 -Jun, 2025
Accepted: 17 -Jun, 2025
Published: 20-Jun, 2025

(IJSEER)
Vol 1 No 1 June 2025

Free Inquiry and Discussion Teaching Methods on Students Academic Performance in Biology in Rivers State.

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Keywords
Free inquiry method, Discussion method, Academic performance, Gender and Critical thinking.

Abstract
This study investigated the impact of free inquiry and discussion teaching methods on students' academic performance in Biology within Obio/Akpor Local Government Area of Rivers State. Grounded in the Constructivist Learning Theory and the Socratic Theory of Dialogue, the study adopted a quasi-experimental, pre-test post-test non-equivalent control group design. A purposive sampling technique was used to select 120 Senior Secondary School II students from two intact classes. The instrument used for data collection was the *Biology Performance Test (BPT)*, which was both validated and tested for reliability. Data analysis was carried out using mean, standard deviation, and Analysis of Covariance (ANCOVA) at a 0.05 level of significance. The results revealed that students exposed to the free inquiry and discussion methods significantly outperformed those taught using discussion methods. Furthermore, the study found no significant gender difference in the academic performance of students taught with the free inquiry methods, indicating their effectiveness for both male and female learners. Most notably, the findings highlighted that these methods enhanced students' ability to apply biological concepts to real-life situations, an essential skill in science education. The study concludes that adopting student-centered teaching strategies such as the free inquiry method not only boosts academic Performance but also fosters critical thinking and practical problem-solving abilities. It recommends the integration of these methods into Biology instruction across senior secondary schools to bridge the gap between theory and practice, and to promote gender-inclusive, and active learning environments.

Background to the Study

Biology, often described as the science of life, plays a critical role in shaping students' understanding of the natural world. In senior secondary education, Biology not only provides a foundational basis for careers in medicine, agriculture, and environmental science but also cultivates scientific reasoning, critical thinking, and the skill to apply theoretical concepts to practical, real-world challenges. Despite these opportunities, traditional lecture-based approaches in secondary schools tend to limit student engagement and lead to rote memorization, rather than encouraging analytical reasoning or the practical application of knowledge (Okafor, 2018).

The free inquiry and discussion method offers an innovative alternative by allowing students to explore topics independently, pose meaningful questions, and engage in in-depth peer discussions. This approach closely mirrors authentic scientific practices and fosters an environment where learners can develop robust critical thinking skills while learning how to apply Biology concepts to solve real-world problems (Adebayo, 2019). For instance, free inquiry enables students to design investigations and draw evidence-based conclusions, while discussion-based learning offers a platform for clarifying

misconceptions, co-constructing knowledge, and identifying practical applications for theoretical concepts (Chin & Osborne, 2020; National Research Council, 2020).

In Nigeria, and particularly in Obio/Akpor Local Government Area of Rivers State, students' performance in Biology has remained consistently low over the years (West African Examinations Council [WAEC], 2022). A major contributing factor to this underperformance is the predominant reliance on teacher-centered, lecture-driven, and examination-focused methods. Such practices do little to stimulate curiosity or encourage the development of critical thinking skills – both of which are essential for bridging the gap between academic learning and real-world application (Obiekwe, 2008; Okebukola, 2016; Akinbobola & Afolabi, 2021).

This study seeks to bridge the gap in current literature by examining how free inquiry and discussion methods not only enhance students' academic performance but also promote critical thinking and the practical application of Biology concepts The study was anchored on two main educational theories: Constructivist Learning Theory and Socratic Theory of Dialogue. Constructivist Learning Theory, advanced by Piaget and Vygotsky, posits that learners construct knowledge actively rather than passively receiving it. In this model, learning occurs when students are engaged in hands-on experiences, exploration, and critical thinking (Vygotsky, 1978). This theory supports the free inquiry method, as it encourages learners to form their own understanding of biological concepts through experimentation and questioning.

In parallel, Socratic Theory of Dialogue, rooted in the teachings of Socrates, emphasizes the importance of asking and answering questions to stimulate critical thinking and illuminate ideas. The discussion method draws heavily from this theory by promoting learner-to-learner and teacher-to-learner dialogue, fostering deeper comprehension and metacognition (Paul & Elder, 2024). Together, these theories underscore the importance of student-centered approaches in enhancing and application of learning outcomes in science education.

Free inquiry and discussion methods are student-centered approaches that enhance engagement, conceptual understanding, and problem-solving in Biology. Free inquiry allows learners to pose questions, form hypotheses, conduct investigations, and interpret results independently, fostering critical thinking (Bell et al., 2023). Discussion methods, on the other hand, enable students to exchange ideas, clarify misconceptions, and apply concepts to real-world problems through peer interaction (Brookfield & Preskill, 2022). Numerous studies have examined the effects of free inquiry and discussion methods on students' academic achievement. A study by Nwagbo (2018) found that students taught with inquiry-based strategies performed significantly better in Biology than those taught with traditional lecture methods. Similarly, Akinbobola and Afolabi (2021) demonstrated that discussion-oriented learning environments improved students' retention and understanding of ecological concepts.

In more recent studies, Ibe (2022) and Ghumdia (2019) found no significant difference in the performance of male and female students when taught using the inquiry-based method. This approach offers a level playing field for both genders, providing equal opportunities to engage with instructional materials and participate actively in the learning process, thereby enhancing comprehension. Consequently, the free inquiry method helps to minimize gender bias in teaching and learning. Obiekwe (2018) examined secondary school students in Enugu State and concluded that both inquiry and discussion methods enhanced students' engagement and achievement, particularly when combined.

These findings align with Chin and Osborne (2020), who emphasized the importance of dialogic interactions in science classrooms. Studies confirm that both methods improve academic performance by promoting active learning, but challenges such as lack of resources, teacher preparation, and student adaptability can affect implementation (Banchi & Bell, 2023; Okoro & Opara, 2019). While empirical

evidence supports their effectiveness, research gaps remain particularly in examining their standalone impacts on Biology learning in Obio/Akpor Local Government Area of Rivers State (Ijeoma & Dike, 2021). Most previous works have focused on guided inquiry rather than free inquiry. This study seeks to fill this gap by assessing the unique and comparative impacts of free inquiry and discussion methods on students' performance in Biology.

Statement of the Problem

Despite government and educational stakeholders' efforts to improve science education, students in Obio/Akpor Local Government Area of Rivers State continue to perform poorly in Biology. WAEC reports (2022) indicate that less than 40% of students who sat for Biology in the district passed with credit-level grades. Many researchers attribute this trend to persistent use of traditional lecture teaching methods that fail to cater to learners' needs and do not promote active engagement with scientific content (Nwagbo, 2018; Udeh, 2019).

Although literature supports the efficacy of learner-centered approaches like free inquiry and discussion, there is limited empirical evidence on their specific impact in the context of Rivers State. Furthermore, Biology teachers often lack the training or confidence to implement these methods effectively. This raises a critical question: would the adoption of free inquiry and discussion methods significantly improve students' academic performance in Biology?

Purpose of the Study

The purpose of this study is to investigate the effects of free inquiry and discussion methods on the academic performance of senior secondary school students in Biology in Rivers East Senatorial District of Rivers State.

Specifically, the study aims to:

1. ascertain the difference in the academic performance of students taught Biology with free inquiry method and those taught with discussion method
2. examine the mean score difference in the critical thinking skills of male and female students taught Biology with free inquiry method

Research Questions

The following research questions guided the study:

1. What is the mean score difference in the academic performance of students taught Biology with the free inquiry method and those taught with discussion method?
2. What is the mean score difference in the critical thinking skills of male and female students taught Biology with the free inquiry method

Hypotheses

The study tested the following null hypothesis at 0.05 level of significance:

Ho_1: There is no significant difference in the academic performance of students taught Biology using the free inquiry method and those taught using the discussion method.

Ho_2: There is no significant difference in the mean score of male and female students taught Biology using the free inquiry method

Significance of the Study

This study holds significant implications for multiple stakeholders:

For Teachers: It provides empirical evidence on alternative instructional strategies that could enhance students' engagement and academic performance in Biology.

For Students: It introduces learning environments that foster curiosity, critical thinking, and independent learning.

For Curriculum Developers: The findings may inform the integration of inquiry-based and discussion-oriented methods into national science curricula.

For Policy makers and Education Planners: The study offers data-driven recommendations that can inform teacher training programs and instructional policies.

For Researchers: It contributes to the growing body of literature on innovative pedagogical practices in science education in Nigeria.

Scope of the Study

This study is delimited to senior secondary school two (SS2) students in public schools within Obio/Akpor Local Government Area of Rivers State. It focuses on the effects of two instructional methods: free inquiry and discussion on Students academic performance in Biology.

Methodology

Research Design

The study was conducted using a quasi-experimental design involving non-randomized pretest, posttest and non-equivalent control group design. This design adopts intact classes in order to avoid the disruption of normal classes. It allows the researcher to assess the effects of the independent variables' free inquiry and discussion methods on the dependent variable, students' academic performance in Biology. Three groups were used: one experimental group taught with the free inquiry method, a second experimental group taught using the discussion method, and a control group taught with the traditional lecture method.

Population of the Study

There are twelve thousand six hundred and ninety (12,690) SS2 Students found in the twenty-eight (28) public senior secondary schools in Obio/Akpor Local Government Area of Rivers state. (Rivers State Senior Secondary Schools Board Biology Students-SS2 Obio/Akpor L.G.A- December 2023. Newly Upgraded Schools in 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023 & 2024)

Sample and Sampling Technique

120 senior secondary schools formed the sample of the study using purposive sampling techniques which match the need of the researcher using an intact class from the two schools in the order of 62 and 58 students in each class. The reason for using a purposive sampling technique is because for any school to be selected the school must have a qualified Biology teacher and a well-equipped science laboratory.

Instrument for Data Collection

Biology Performance Test (BPT) was used to collect relevant data for this study. BPT was self-designed by the researcher and measured students' academic performance in Biology. It consisted of 50 multiple-choice items covering key SS2 Biology topics such as ecology, nutrition, and cell biology. The test was used for both pre-test and post-test assessments. The BPT was constructed based on the SS2 Biology curriculum, using a table of specification to ensure content validity and coverage of different cognitive levels (knowledge, comprehension, application, and analysis)

Validity of the Instrument

To ensure content and face validity, the instrument was reviewed by three experts in Biology education and educational measurement from Ignatius Ajuru University of Education. Their input guided the refinement of item clarity, relevance, and alignment with learning objectives.

Reliability of the Instrument

The reliability of the BAT was established using the Kuder-Richardson Formula 20 (KR-20), appropriate for dichotomously scored items. A pilot test conducted with 30 SS2 students (not part of the main study) yielded a reliability coefficient of 0.87, indicating high internal consistency.

Method of Data Collection

The study followed three key stages: The pretests were administered to all groups to assess baseline knowledge. Then followed with the treatment Phase that took place over a period of six weeks. Group 1 was taught using free inquiry (students generated questions, conducted experiments, drew conclusions) and Group 2 was taught using discussion methods. A Post-test of the same BPT was administered to assess changes in academic performance. Teachers in each school were trained before the treatment phase to ensure fidelity of the instructional methods.

Method of Data Analysis

Data collected were analyzed using both descriptive and inferential statistics: Mean and standard deviation were used to answer the research questions. Analysis of Covariance (ANCOVA) was used to test the hypotheses at a 0.05 level of significance. The pre-test scores served as the covariate to control for initial differences among the groups.

Results and Discussion

Research Question One: 1. What is the mean score difference in the academic performance of students taught Biology with the free inquiry method and those taught with discussion method?

Table 1: Mean and standard deviation of students' academic performance score in Biology

Groups		Pre-test		Post-test		Mean Gain
	n	Mean	SD	Mean	SD	Scores
Free inquiry method	62	54.87	0.77	80.09	0.95	25.22
Discussion Method	58	55.00	0.80	75.05	0.98	20.05
Mean difference						**5.17**

From Table 1, it is shown that Students exposed to the Free inquiry method had a mean performance score of **54.87** with standard deviation of **0.77**. at pretest and mean of **80.09** with standard deviation of **0.95** at post-test. The mean gain score of students exposed to the Free inquiry method was **25.22** showing a significant improvement in the academic performance of students. On the other hand, students who were exposed to the discussion method had a mean performance score of **55.00** at pre-test with standard deviation of **0.80** at posttest and pretest mean of **75.05** with standard deviation of **0.98** at post-test. The mean gain scores of the students exposed to the discussion method was 20.05. indicating some improvement but not as much as the Free inquiry group. The small difference in standard deviation scores shows that students were moderately heterogeneous in their responses to the questions and the mean difference of 5.17in favour of those taught with free inquiry teaching method reveals that the Free inquiry method of teaching has more effect on the mean performance score of students in Biology compared to discussion methods.

Research Question One: 2. What is the mean score difference in the male and female students taught Biology with the free inquiry method

Table 2: Mean and standard deviation of critical thinking skill of male and female students' taught Biology with free inquiry methods

Gender	n	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Mean Gain Scores
Male	29	54.93	0.80	80.14	0.93	25.21
Female	31	54.81	0.75	80.05	0.97	25.24
Mean difference						0.03

Results in Table 2 revealed that at the pre-test, male students had a mean performance score of 54.93 with a standard deviation of 0.80 and 80.14 at posttest with standard deviation of 0.93, While their female had a mean performance score of 54.81 with standard deviation of 0.75 at pretest The difference is very small (0.12 points), meaning both groups started at almost the same level. At the post-test, female students had a mean performance score of 80.05 with standard deviation of 0.97. Again, a very slight difference (0.09 points), suggesting both genders performed almost equally well after the teaching. The mean gain score of the males was 25.21 while the mean gain score of the female students was 25.24. Practically identical improvement in performance. All SDs are less than 1, this means the scores are tightly clustered (students performed very similarly within each group).This shows homogeneous performance and a reliable intervention effect. The mean performance scores of males and females are very similar,and their mean difference are very small indicating no substantial gender difference in overall performance.

Hypothesis 1: There is no significant difference in the academic performance of students taught Biology using the free inquiry method and those taught using the discussion method.

Table 3: **Summary of Analysis of covariance (ANCOVA) of students' performance in Biology taught the free inquiry method and those taught using the discussion method.**

Tests of Between-Subjects Effects

Dependent Variable: Post_Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	760.848a	2	380.424	409.023	.000	.875
Intercept	121.429	1	121.429	130.558	.000	.527
Pretest	1.116	1	1.116	1.200	.276	.010
Group	759.396	1	759.396	816.485	.000	.875
Error	108.819	117	.930			
Total	722937.769	120				
Corrected Total	869.667	119				

a. R Squared = .875 (Adjusted R Squared = .873)

Result of the analysis in Table 3 shows that teaching methods are a significant factor on students' performance in Biology; F (1, 117) = 816.485, P = .000. p-value for (methods) Group is .000 which is less than .05.Thus, the null hypothesis of no significant difference in the mean performance scores of students taught Biology using Free inquiry and those taught with discussion methods was rejected. This is because the exact probability value of .000 is less than the level of significance set at 0.05.

Therefore, the researcher concludes that there is a significant difference in the mean performance scores of students taught Biology using Free inquiry methods and those taught with discussion methods.

Hypothesis 2: There is no significant difference male and female students taught Biology using the free inquiry method

Table 4: Summary of Analysis of covariance (ANCOVA) of significant difference in the male and female students taught Biology Using the free Inquiry Method
Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.596b	2	1.298	1.474	.238	.049
Intercept	62.400	1	62.400	70.852	.000	.554
Pretest	.574	1	.574	.652	.423	.011
Gender	1.950	1	1.950	2.214	.142	.037
Error	50.200	57	.881			
Total	384888.450	60				
Corrected Total	52.796	59				

R Squared = .049 (Adjusted R Squared = .016)

After controlling for pre-test scores, gender did not have a statistically significant effect on students' critical thinking performance ($F(1, 59) = 2.214$, $p = .142$) This suggests that both male and female students benefited similarly from the Free Inquiry method . p-value for gender = .142 > 0.05 we fail to reject the null hypothesis, meaning there is no significant difference in the posttest Biology scores between male and female students taught using the free inquiry method. The observed performance differences are more influenced by pretest knowledge rather than gender, suggesting that free inquiry enhances learning regardless of gender.

Discussion

The analysis and findings of this study showed that the experimental group taught using the free inquiry method significantly outperformed the control group, which was taught through the discussion method, in Biology. This enhanced performance in the experimental group may be attributed to the active involvement of students during their learning process, where they had opportunities to apply what they had learned independently and to explore and discover new knowledge on their own.

The findings of this study are consistent with those of Nwagbo (2018), who reported that students taught using free inquiry-based strategies performed significantly better in Biology than those instructed through traditional discussion methods. Similarly, the results support the conclusions of Ogumah et al. (2019), who emphasized that the free inquiry-based teaching method enables students to construct new concepts by building on their prior knowledge, experiences, discoveries, and existing conceptions. Furthermore, the inquiry-based approach engages learners through multiple modalities visual, auditory, and kinesthetic via hands-on activities, which work synergistically to enhance

understanding, maintain interest, and sustain attention throughout the learning process. The success of the free inquiry method in this study suggests that when students take ownership of their learning through exploration and problem-solving, they tend to perform better. This supports the constructivist view that active participation leads to meaningful learning (Vygotsky, 1978).

The findings on gender in the study revealed that male students obtained a higher mean score than their female counterparts even though the difference was not significant. This may be due to the fact that the inquiry-based method of teaching offered fair interaction to both sexes in the study of general chemistry. This result agrees with the findings of Ibe (2022) and Ghumdia (2019) who found no significant difference in the performance of male and female students when taught using the free inquiry method. This approach offers a level playing field for both genders, providing equal opportunities to engage with instructional materials and participate actively in the learning process, thereby enhancing critical thinking, comprehension. Consequently, the free inquiry method helps to minimize gender bias in teaching and learning. Additionally, the discussion method's effectiveness confirms the value of dialogic teaching in developing students' reasoning abilities and knowledge construction, as observed by Brookfield and Preskill (2020). However, its slightly lower impact compared to free inquiry may be due to limitations in students' communication skills or time constraints during implementation.

Classroom Application of Findings

The outcome of this study highlights the critical importance of adopting inquiry-based teaching approaches in the instruction of General Chemistry at the Colleges of Education. Such methods significantly foster the development of problem-solving skills among student-teachers, enabling them to grasp and internalize scientific concepts more effectively and efficiently. Free inquiry method encourages learners to engage in meaningful, hands-on experiences, to bring out new ideas by themselves, through active participation in investigative activities such as observation, questioning, experimentation, and analysis students are able to construct knowledge independently. This learner-centered model not only deepens understanding but also promotes critical thinking and autonomy in the learning process. Given these benefits, it is essential for Biology educators to place greater emphasis on the use of inquiry-driven strategies during instructional periods. This shift in pedagogy will support the cultivation of analytical and problem-solving competencies in students, which are crucial for both academic performance and future professional practice.

Conclusion

Based on the findings, it is evident that teaching strategies significantly influence students' academic performance. The use of free inquiry and discussion methods in Biology classrooms can bridge gaps in engagement, deepen conceptual understanding, and promote higher Performance

Therefore, teacher-centered methods such as lectures, though still common, may no longer be adequate for meeting the cognitive and practical needs of modern science learners. Active learning approaches that place students at the center of knowledge creation , particularly free inquiry methods offer more impactful results.

Recommendations

In line with the findings of this study, the following recommendations are made:

1. Biology teachers should be trained and encouraged to adopt free inquiry and discussion methods to enhance teaching effectiveness and student performance.
2. Educational stakeholders, including curriculum planners and teacher training institutions, should ensure that professional development programs emphasize gender-inclusive teaching strategies.

This will help educators create supportive classroom environments where all students male and female alike feel encouraged to participate, inquire, and collaborate effectively

3. Further studies should be encouraged in other science subjects to determine the broader applicability of free inquiry teaching methods.

Suggestions for Further Studies

1. Longitudinal studies to assess the long-term impact of Free inquiry-based learning on students' academic growth.
2. Investigating how this method influences students' interest, motivation, and attitudes toward science.
3. A study on the challenges tTeachers face in implementing free inquiry and discussion methods in Nigerian secondary schools.

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