

EFFECT OF INQUIRY-BASED INSTRUCTION ON STUDENTS IN BIOLOGY: IMPLICATIONS FOR SCIENCE EDUCATION IN YALA L. G. A, CROSS RIVER STATE

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Abstract

The study investigated the effect of inquiry-based Instructional method on student academic achievement in biology with specific implications for science education in Yala Local Government Area of Cross River State, Nigeria. The study was motivated by persistent poor performance of students in Biology as reported by the Cross River State Examination Board between 2018 and 2020, and the continued reliance on teacher-centered instructional strategies in science classrooms. Two research questions and two hypotheses guided the study formulated and tested at 0.05 α -level. A pre-test post-test quasi-experimental research design was used for the study. A multi-stage sample of 60 SS II biology students from two intact classes drawn from a population of 1,613 students in 25 public secondary schools. The Biology Performance Test (BPT) served as the main instrument for data collection. The Biology Performance Test (BPT), was used for data collection. Data were analysed using mean standard deviation mean gain scores and mean gain difference to answer research questions while the null hypotheses were tested using analysis of Covariance (ANCOVA). Findings of the study showed that there is no significant mean difference in the achievement scores between students taught biology using inquiry-based method and those taught biology using traditional lecture method. $F(1, 177) = 237.91$; $p \leq 0.05$ However, those taught Biology concept using inquiry-based method exhibited significantly higher achievement scores than those taught with traditional lecture method, $F(1, 158) = 253.14$; $p \leq 0.05$ Also there is no significant mean difference in the achievement score between male and female students taught biology using inquiry-based method. $t(99) = 1.275$; $p > 0.05$ This implies that inquiry base method is gender friendly hence it enhanced academic achievement in both male and female biology Students. Therefore, among others the use of inquiry-based instruction should be encouraged among teachers of Biology to improve student's academic achievement in secondary education.

Keywords: Biology, Inquiry-based Instruction, Science Education, Students

Introduction

Secondary school plays a huge role in shaping a student's future. At this stage, students usually branch into two main paths: the Science Group or the Humanities Group. Subjects like physics, chemistry, and biology often feel tricky to many learners. Biology stands out as especially challenging it's packed with specialized terms and involves plenty of hands-on learning. That's where a teacher's role becomes crucial. By sparking curiosity through inquiry-based activities and guiding students on real biological issues, teachers can make a big difference in how students grasp the subject. As Bransford, et al (2012) point out cited in Mehboob, Mehboob, and Adeyemi (2021) effective teaching strategies can help students tackle these challenges head-on.

Education is an essential and indispensable part of human life. It is described as the cultivation of wise, hope and respect which will be taken as belief shared in life. Education enables human in achieving high technological advancement (Oscarsson et al., 2012; Ramankulov et al., 2016). The more developed the life, the higher the necessity of education would be. Science education is included to the education part which produces scientifically-skilled (Septiani&Rustaman, 2017) and literate citizens, there are three major branches of science i.e. Biology, Chemistry, and Physics which are learnt in senior secondary school level in the Nigerian education system (Aina & Ayodele, 2018; Akintola & Ahmed, 2018). These sciences help students to prepare for pure science and pure science-based courses in their tertiary education level and even their future professions (Entrich, 2015).

Education can take place in both formal and informal contexts, such as schools, colleges, and universities, as well as at home and in the community. It may include several types of instruction such as classroom lectures, online courses, experiential learning, and practical training. Education is the process of acquiring knowledge, skills, attitudes, beliefs, and habits through many modes of learning, including teaching, training, research, and self-study. (Mezirow 2018).

Science education plays a critical role in preparing learners with the knowledge, skills, and attitudes necessary for scientific literacy, problem-solving, and participation in a technologically driven society. At the secondary school level in Nigeria, science subjects namely Biology, Chemistry, and Physics form the foundation for scientific and science-related careers. Among these subjects, Biology occupies a central position due to its relevance to health, agriculture, environmental management, and biotechnology. Despite its importance, students' achievement in Biology and other science subjects at the senior secondary school level has remained consistently low, as evidenced by reports from the West African

Examinations Council (WAEC). Chief Examiners' reports repeatedly highlight students' weak conceptual understanding, poor application of scientific principles, and inability to interpret data and diagrams. These challenges have been largely attributed to ineffective teaching strategies that emphasize rote memorization rather than active engagement in scientific inquiry.

However, despite the recognized importance of science education, student performance in science subjects across Nigerian secondary schools remains a persistent concern (Akinwumi, 2022). Conventional lecture-based teaching methods, which dominate Nigerian classrooms, have often been criticized for promoting rote learning rather than conceptual understanding and learner engagement (Ogbaga, Eze, & Uche, 2023). To address these challenges, educationists and researchers have increasingly advocated for inquiry-based instructional methods (IBIM) as a viable alternative to traditional pedagogies. Inquiry-based methods emphasize student-centered learning, where learners actively construct knowledge through observation, questioning, experimentation, and reflection. These methods are particularly relevant to science education, where they mirror the practices of scientific investigation (Tijani, 2023).

In the Nigerian context, empirical studies have consistently demonstrated the efficacy of inquiry-based approaches in enhancing students' academic performance and interest in science. For instance, Danjuma, Maikano, & Yawe (2022) found that integrated inquiry-based science teaching significantly improved junior secondary school students' beliefs in science and increased their interest in the subject. Similarly, Ogbaga et al. (2023), in a quasi-experimental study conducted in Delta State, reported that guided inquiry methods led to significantly higher student achievement and retention in basic science compared to conventional lecture methods.

In recent years, the Nigerian government has made efforts to improve the quality of education in the country. The government has introduced various policies and programs, including the establishment of more universities, the implementation of the National Policy on Education, and the introduction of new curricula.

Education in Nigeria is overseen by the federal government, as well as state and local governments. Nigeria has a 6-3-3-4 education system, which means six years of primary education, three years of junior secondary education, three years of senior secondary education, and four years of tertiary education (Badejo & Odewale, 2018). Although primary education in Nigeria is both required and largely free, many kids choose not to go to school because of lack of resources, traditional beliefs, and safety concerns. The primary school curriculum covers

fundamental courses like science, social studies, arithmetic, and English. Junior secondary and senior secondary levels make up secondary education in Nigeria. At the junior secondary level, students continue studying the fundamental topics while also taking vocational classes like home economics, technical drawing, and agriculture. At the senior secondary level, students specialize in either the sciences or the humanities, and they are required to sit for the West African Senior School Certificate Examination (WASSCE) before proceeding to tertiary education. (Seyi, 2017).

According to the National Policy on Education (2004), Nigeria's philosophy of education is based on three broad areas: the development of the individual into a sound and effective citizen, the full integration of the individual into the community, and the provision of equal access to educational opportunities for all citizens of the country at the primary, secondary, and higher education levels. the inculcation of the type of values and attitudes for the survival of the individual and Nigerian society, the training of the mind in the understanding of the world around, and the acquisition of appropriate skills and the development of mental, physical, and social abilities and competencies as equipment for the individual to live and contribute to the development of the society. This can be achieved through the teaching of relevant subjects such as biology.

Biology is a natural science topic and one of the compulsory subjects taught at the ordinary level in Nigeria's secondary school curriculum. The subject is required for many fields of study that contribute to the national economy, including medicine, agriculture, biotechnology, and nursing (Ghumdia& Adams, 2017). Learning Biology provides students with knowledge and abilities that will help them tackle societal difficulties, particularly those involving prevalent diseases, pollution, and genetics. Furthermore, biology subjects lead to self-awareness and understanding of how the body works (Kareem, 2018), so they deserve to be included in school curricula, as well as an emphasis on the teaching-learning continuum.

It is, therefore, important that schools utilize effective methods to teach this subject so that students achieve the planned objectives. Despite the importance of science and its applications, the performance of science students at West African Examination Council (WAEC) has not been satisfactory. Research has shown that for several years the performance of students in science has been very poor (NERDC, 2004; Eniayeju, 2010; Obi &Ewuzie, 2014). Analysis of results given by West African Examination Council (WAEC) Chief Examiners reports showed the average mean performance score of students who sat for Biology for several years in 2017, 2018, 2019, 2020 and 2023 with a raw mean score 18 and standard deviation

of 6.00 for 2017, 14 and standard deviation of 0.6.48 for 2018, for 2019 with a raw score of 31 and standard deviation of 9.00, the performance of candidate in 2020 was poorer than that of the last previous year with raw mean score of 26 and standard deviation of 10.68 while in 2022 the performance of candidate this year with a raw mean score of 37 and standard deviation of 9.54 was poorer than that of 2021 with raw mean score of 40 and standard deviation of 10.00. And in 2023 the performance of candidate that year with a population of 1, 068,564 and a raw mean score of 31 and standard deviation of 10.91 was worse than that of 2022 with a population of 1,048,242 respectively (WAEC Chief Examiners Reports). The continual dismal performance rate is a glaring indication that Nigeria's secondary education system just like the tertiary and primary system is troubled and in a state of decay (Obi &Ewuzie, 2014). WAEC Chief Examiners' Reports (2023) revealed that identification of biology concepts which students find difficult is necessary in addressing poor performance in the subject.

Several studies attributed students' achievement or failure in science subject to various reasons. Akor (2013) opined that lack of equipment in science affects teaching and learning which also affects performance in science. Among many reasons proffered by researchers, such as qualification of teachers, students' parental background, facilities, misconception of concepts appears to be significant factors affecting students' achievement in science subject. Chief Examiners' Reports (2021) pointed out that lack of in depth understanding of various concepts and inability to present points in a coherent order, poor interpretation of the graph on predator-prey relationship in question 3 and poor drawing of the DNA molecule etc., as the students' weaknesses in Biology. WAEC Chief Examiners' Report (2021) Furthermore, West African Examination Chief Examiners Reports on proffered remedy to overcome the weakness, candidate should study topics on adaptation and ecology properly, and standard text books should be used to study.

Students' non-participation in the learning process does not create an environment that could challenge students to change the disequilibrium in their mind-set to tackle the wrong concepts they brought to the classroom. Hence, the need to involve students in a more proactive learning process such as the inquiry-based learning. Inquiry-based learning, as defined by Marcus (2017), is a type of active learning that begins with posing questions, problems, or scenarios, rather than simply presenting established facts or portraying a smooth path to knowledge. It is important to define inquiry-based learning from both learner and teacher perspectives. From the students' point of view, inquiry bases learning focuses on investigating an open question or problem. They must use evidence-based reasoning and creativity. Science educators (Lazonder& Harmsen, 2016) science educators

advocate for shifting from conventional lecture-based methods toward student-centered, inquiry-driven pedagogies that actively involve learners in the process of scientific investigation, that (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 on the basis of evidence (Nnadi, 2011). Koyunlu Ünlü, Z., & Dokme, İ. (2020). Pointed out that inquiry-based learning supported by digital tools improves scientific inquiry skills, problem solving, and conceptual understanding. They must experience the process of knowing and be able to give their own justification knowledge and interpretation of biology concepts especially concepts on Adaptation.

Lecture strategy is a teaching strategy in which the teacher presents a verbal discourse on a particular subject, theme or concept to the learners Okoli (2016). Lecture strategy is an ideal way of presentation of facts in sequences order and it is also used to throw light and clarify information or problems. Lecture strategy is used primarily to introduce students to a new subject but it is also a valuable strategy for summarizing ideas, showing relationship between theory and practice and re-emphasizing main point Sola and Ojo (2017)

Students' academic achievement is strongly influenced by the quality of teaching and the effectiveness with which the school curriculum is implemented. Teachers occupy a central position in the educational process, as they are responsible for translating educational policies into meaningful classroom practices during their interactions with learners. Through instructional decisions, pedagogical strategies, and assessment practices, teachers directly shape students' learning experiences and outcomes (Ajayi, 2017; Oni, 2017). The persistent poor performance of students in Senior Secondary School Certificate Examination (SSCE) Biology has raised serious concerns among educators and stakeholders. The decline achievement in biological sciences has prompted professional bodies, particularly the Science Teachers Association of Nigeria (STAN), to intensify efforts aimed at improving science education.

Another factor that plays an important role in learner's skills is gender. Gender is defined by Ugwu and Nwagbo (2019) as the socially or culturally constructed characteristics and roles which are ascribed to males and females in any society. Review of literature has shown inconsistency in the results of male and female students' academic performance in Biology and science at large (Tofi, Usman & Lakpini, 2021). For instance, Alamri (2018) found that female students performed better than the male students; conversely Eze and Obiekwe (2017)

revealed that boys performed better than their female counterparts. While Timayi (2016) and Kingdom-Aaron, Etokerenand Okwelle (2019) found no significant difference between male and female students performance scores. Similarly, Linn and Kanazawa as cited in Peni, (2016) conducted a longitudinal study of sex differences in reasoning abilities among students of ages 7, 11 and 16. They concluded that there was no gender difference in reasoning ability at the early years of childhood. However, Erinoshosha as cited in Peni (2016) opined that female students do not perform well in science because they do not experience science through activity. Jenkins as cited in Peni, (2016) argued that girls' performances are improved when science is related to their concerns through effective instructional methodologies.

In a rapidly growing and challenging world today, the demand for pedagogical approaches which foster the acquisition of 21st century competencies among students has become imperative. So far, studies have shown that the persistent use of traditional teaching methods do not promote science process skills such as critical thinking, creativity, communication and manipulative skills among students. Despite the poor performance of students in Biology, Biology has been an issue attracting the attention of researchers and science educators. Educators have therefore suggested the use of alternative strategies such as inquiry strategy for teaching biology.

Purpose of the Study

The purpose of this study was to examine the effect of inquiry-based instructional method on students' academic achievement and retention in Biology, at the senior secondary school level in Yala Local Government Area of Cross River State. Specifically, the study sought to:

1. Determine the difference in mean achievement scores of students taught Biology using inquiry-based instruction and those taught using the traditional lecture method.
2. Examine the difference in mean achievement scores of male and female students taught Biology using inquiry-based instruction.

Research Questions

1. What difference exists in the mean achievement scores between students taught biology using inquiry-based instruction and those taught using traditional lecture method?
2. What difference exists in the mean achievement score of male and female students taught biology using inquiry –based instruction?

Research Hypothesis

1. There is no significant difference in the mean achievement scores of

students taught biology using inquiry-based instruction and those taught biology using traditional lecture method.

2. There is no significant difference in the mean achievement score between male and female students taught biology using inquiry -based instruction.

Methodology

The study adopted a pre-test, post-test non-equivalent quasi-experimental research design was used. Sixty (60) students and two schools were selected through multi-stage sampling technique (purposive, stratified, and random sampling technique), from the population of 1,613 SSII Biology students in 25 public secondary schools under the Cross River State Universal Basic Education Board (SUBEB), yala LGA, from two intact classes. Instruments for data collection included the Biology Performance Test (BPT), the instruments was adopted by the researcher, validated by two experts in Science and Mathematics Education. Reliability testing yielded 0.90. The experimental group was taught using inquiry-based instructional strategies, while the control group received instruction through the lecture method. Treatment lasted for four weeks. Data were analyzed using mean, standard deviation, and ANCOVA at 0.05 level of significance.

Results.

Research Question One:What difference exists in the mean achievement scores between students taught biology using inquiry-based instruction and those taught using traditional lecture method?

Table 1: Mean and Standard Deviation of Post-test Scores of Academic achievement of biology students in Experimental and Control Groups

Treatment	N	Mean	SD	Mean Diff
Experimental	60	19.37	3.52	9.89
Control	60	9.48	3.41	

The result in Table 1 presents a comparison of the mean achievement scores of experimental and control groups in the study. The experimental group recorded a mean score of 19.37 and a standard deviation of 3.52 in contrast to the control group with a mean score of 9.48 and standard deviation of 3.41. The comparisons showed that there was relatively marked difference in achievement between experimental group and control group in favour of the experimental group that had higher mean with a mean difference of 9.89.

Research Question Two: What difference exists in the mean achievement score of male and female students taught biology using inquiry –based instruction?

Table 2: Mean and Standard Deviation of Post-test Achievement Scores of Male and Female students in the Experimental group

Gender	N	Mean	SD	Mean Diff
Male	60	18.25	3.24	0.36
Female	60	18.61	3.21	

The result in Table 2 shows a comparison of the male and female achievement scores of in the experimental study. Male students recorded a mean score of 18.25 and a standard deviation of 3.24 while the female students recorded mean score of 18.61 and a standard deviation of 3.21. The results showed female students taught with inquiry-based learning had a higher post-test mean than the males

Hypotheses Testing

H_{01} . There is no significant difference in the mean achievement scores of students taught biology using inquiry-based instruction and those taught biology using traditional lecture method.

Table 3: Two Way Analysis Covariance (ANCOVA) for Post-test Achievement Scores in the Experimental and Control Groups.

Source	Type III sum of squares	Df	Mean square	F	Sig.
Corrected model	3400.57 ^a	3	1244.70	78.27	0.001
Intercept	35645.49	1	35645.49	2.91E3	0.001
Treatment	3414.30	1	3414.30	237.91	0.001
Error	2511.46	177	16.53		
Total	43484.8	178			
Corrected Total	5835.35	178			

Significant at $p \leq 0.05$

From Table 3, the calculated $F(1, 177) = 237.91$; $p \leq 0.05$ revealed that there is significant difference in the academic achievement of students in the experimental and control groups. Thus, the null hypothesis is not accepted. This implies that students in the experimental group perform better than those in control group or have higher academic achievement.

H_{02} . There is no significant difference in the mean achievement score between male and female students taught biology using inquiry -based instruction.

Table 4: t-test Analysis of Post-test Achievement Scores between Male and Female Students in the Experimental Group

Gender	N	Mean	Std. Deviation	Std. Error mean	Df	t value	P
Male	60	18.25	3.24	0.57	99	1.317	0.169
Female	60	18.61	3.21	0.56			

Significance at $p > 0.05$

From Table 4, the calculated $t(99) = 1.317$, $p > 0.05$ showed that there was no significant difference between the achievement score of male and female students using the inquiry-based instruction. Hence, the null hypothesis is retained. This implies that inquiry base instruction is gender unbiased; hence it enhanced achievement in both male and female biology students

Discussion of Findings

Concerning student's achievement score based on their exposure to inquiry-based learning. There is no significant difference in the mean achievement scores of students taught biology using inquiry-based instruction and those taught biology using traditional lecture method. However, the result showed that there is significant difference in the academic achievement of students in the experimental group over control groups, following field experience, students who were taught with inquiry-based method gained more achievement as a result of their engagement with the available resources as compared to those taught using traditional Lecture Method. Students in inquiry-based classroom were highly engaged with the available resources thereby enhancing student achievement. The findings agree with Mukhwana (2016) who found out that students taught by IBL had higher levels of acquisition of SPS and higher achievement when compared with those taught using TL. As regard to the second objective of this study, students' achievement score based on gender, shows there is no significant mean difference in the achievement score of male and female students taught biology using inquiry -based method. The finding also showed that inquiry-based learning is effective in enhancing academic achievement among male and female students in both experimental and control groups. This finding is not odd to Issaka (2014) who found out that students in the

experimental group performed better than the students in the control group. The findings also show that students who were instructed with inquiry-based method have higher capacity than their counterpart students who were exposed to traditional method. While variations in effectiveness exist across specific inquiry models and educational contexts, the overall trend suggests that inquiry-based methods hold significant promise for addressing persistent issues in science teaching and learning. Consequently, adopting such approaches more widely could play a crucial role in achieving national education goals and aligning classroom practices with global standards in science education.

Conclusion

From the findings of this study, the following conclusions was drawn: Students exposed to inquiry-based instruction demonstrate higher mean academic achievement. There is a marked increase in the level of interest shown by the experimental group compared to the control group, in favour of the experimental group. Inquiry-based instruction enhances academic achievement of student, equally among both male and female.

Recommendations

It is therefore recommended that:

1. The use of inquiry-based instruction should be encouraged among Biology teachers to improve students' academic achievement.
2. Both male and female senior secondary school students should be taught Biology using inquiry-based instruction, as it enhances academic achievement of learners.
3. Additionally, Biology teachers should be sponsored by the government and private school owners to attend regular courses, workshops, seminars, and in-house training on the effective use of inquiry-based instruction to maximize students' academic achievement.

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