

# Effects of Laboratory and Inquiry Methods on Students' Mathematics Achievement in Senior Secondary Schools in Delta North Senatorial District

OKOISAMA, Chukwuekwu Marian and Dr. S. B. Ijeh

Department of Science Education, Delta State University, Abraka

**Abstract:** *The study investigated the effects of laboratory and inquiry methods on students' Mathematics academic achievement in senior secondary schools in Delta North Senatorial District. The research design was a 3x2 factorial, pretest, posttest planned variation design. 5813 SSII students made up the population. 319 SSII Mathematics students sampled with stratified random sampling technique took part in the study. MAT was used to collect data. MAT's r-value, which was calculated using Kuder-Richardson Formula 21, was 0.78. The findings revealed a significant difference in the mean achievement scores among students who were taught mathematics using laboratory, inquiry, and lecture methods, with the laboratory and inquiry methods coming out on top. The results also revealed a significant interaction between the teaching method and sex on students' achievement in mathematics. The study came to the conclusion that, in terms of raising students' mathematics achievement, laboratory and inquiry methods are superior to the lecture method. The study recommends that secondary school mathematics teachers should use laboratory and inquiry methods in their lessons, and that school administrators should offer these teachers in-service training to give them the necessary skills to ensure the successful implementation of laboratory and inquiry methods as well as other cutting-edge techniques.*

**Keywords:** Laboratory Method, Inquiry Method, Achievement

## Introduction

Education is the most potent weapon for long-term growth of any nation. Education is the process of imparting information, skills, and values to future generations. Adequate education facilitates individuals' efficient absorption into their surrounding environment. With the purpose of ensuring that education is applicable to people and society, governments should promote sound education, particularly in this era of scientific and technological growth. Science and Technology are advancing at breakneck speed, which is quite amazing. To a considerable measure, Mathematics is responsible for all of humanity's remarkable achievements (Alake, 2015).

The word "mathematics" is derived from a Greek verb that means "to learn" (Suleiman & Hammed, 2019). The science of counting, measuring, and describing objects and shapes is known as mathematics. It is concerned with logical reasoning and numerical calculations. Mathematics is often regarded as the bedrock of Science and Technology, without which a country would never be affluent or economically self-sufficient. This emphasizes the necessity of mathematical ability for all students at all levels of education, as well as a cause for making Mathematics a mandatory subject in secondary school curricula. This significance reflects the importance of the role it plays in modern society. Mathematics, according to Anibueze (2015), is the science that investigates and describes quantities, numbers, measurements, and their relationships. Mathematics is a tool for advancing any science-based subject, such as astronomy, graphics, technology, analytical reasoning, and industry.

Even though mathematics is important in Nigeria, students usually do badly on external exams in this subject. The WAEC Chief Examiner's report on Mathematics verified this trend of children performing poorly in WASSCE (Report of the Chief Examiner for WACE, 2017–2021). Poor teaching methods, among others, may be the cause for students' poor Mathematics achievement in Mathematics. The lecture approach has long been the most popular way to teach mathematics in secondary schools in Nigeria. A teacher-centered mode of instruction known as the lecture method involves the teacher imparting knowledge to the students. The students pay attention to the teacher and have few or no opportunities to offer questions as the lecture develops. According to Ajaja (2016), a lecture is a speech, a talk, a lesson, or other sorts of verbal presentation to students by a teacher. The lecture technique of instruction, according to the author, is a "talk-chalk" method that has the following advantages: coverage of large volume of content, instructing a sizable student body, imparting knowledge to students, generating interest in a topic, presenting students with new information, and helping students to clarify and understand content. The basic problem with the lecture method is the students' lack of active participation, lack of student-student connection, and lack of interaction with the learning material. The lecture approach may be held accountable for students' poor performance in mathematics because of their passive participation during instruction.

The WAEC Chief Examiner's report (2021) advised mathematics teachers to make the teaching and study of mathematics far more engaging and practical as a way to improve students' low performance in mathematics. Adoption of proper teaching method(s) is one way Mathematics teachers can make the teaching and learning of Mathematics more entertaining. Mathematics teachers can use a range of teaching methods for teaching and learning the subject. However, due to the significant benefits that these two teaching methods have over others, the study exclusively focused on laboratory and inquiry teaching methods.

Laboratory teaching method, according to Joshi (2018), is a unique method of teaching that is crucial to successful science instruction. With this approach, the teacher does not lecture or provide experimentation demonstrations. Instead, students are urged to do the experiments themselves in order to test the scientific theories and rules. The students are provided with the necessary materials and tools for the lab as well as detailed instructions on how to conduct their experiments independently and with the least amount of help. The observations are recorded, and conclusions are arrived at. It allows students to engage in the process and gain an understanding of scientific methods while also helping them to understand complex abstract topics. Joshi (2008) emphasised that as students learn via their own experience, observation, testing, and verification, knowledge and skills produced through a laboratory teaching technique are more lasting and permanent. A laboratory teaching approach to mathematics aids in the development of equipment, instrument, and apparatus familiarity. Through practical practise, students learn how to manipulate objects and become proficient at reading different scales. The results and recommendations are utilised to gain a deeper understanding of mathematical ideas. By adopting the laboratory teaching technique, abstract ideas may be made concrete, which also boosts students' enthusiasm and interest in learning mathematics (Osborne, 2012). Activity-based classes that allow students to use equipment and apparatus to better grasp the subject matter help them learn the content more effectively.

According to Millar (2014), the laboratory teaching approach is the process through which materials and apparatus are carefully and critically combined to persuade the student of the validity and authenticity of the scientific worldview. The laboratory teaching approach exposes students to a variety of practical tasks. If done appropriately beginning in early secondary school, practical practise in mathematics can help students develop their critical thinking skills. Students are put at the centre of their education through practical work, allowing them to participate with mathematics rather than just study about it (Ng'ethe, 2016). Studies have shown that laboratory teaching method bears beneficial boost on students' academic achievement (Bajon, 2015; Chibabi, Umoru, Onah & Itodo, 2018). Nevertheless, will the use of laboratory teaching method be more effective in boosting students' achievement in Mathematics more than inquiry teaching method? This is the major rationale for this study.

According to Chukwudebem (2019), the inquiry teaching technique is a type of instruction in which the student conducts a thorough investigation, often with little supervision from the teacher, in an effort to find and create solutions to problems that have been identified. Science teachers may also refer to a method of asking, seeking information, or learning about things as inquiry teaching. Open and guided inquiry teaching methods are the two main categories of inquiry-based instruction. In the open inquiry method, students are not guided but in guided inquiry method, the teacher provides guidance for students. The study focused on guided inquiry teaching method since it is delimited to Senior Secondary School students.

Guided inquiry method is one teaching method that can be applied in teaching Mathematics (Kelubia, 2021). When taught through guided inquiry, children engage in many of the actions and thinking processes that scientists use to create new knowledge. Teachers should be encouraged to replace traditional teacher-centered instructional practises, such as a focus on textbooks and lectures, with inquiry-oriented approaches that engage students' interest in science and give them opportunities to use appropriate laboratory techniques to gather evidence. Students should be required to solve problems using logic and evidence.

According to Sandoval and Reiser (2014), students must create a community of practise similar to how scientists perform their job in order to create an inquiry-based learning environment. The process of knowing and the justification of knowledge are experienced by students in real guided inquiry-teaching activities (Ali, 2014). Students take the initiative to investigate phenomena and provide hypotheses, create and carry out experiments to verify or refute their ideas, analyse data, draw conclusions from experimental data, design and construct models, or any combination of these. Research-emergent understanding of the learning process underpins the guided inquiry teaching (Ebiguwere, 2018). In order to ensure that students actively participate during teaching, utilising a variety of hands-on activities to show mathematical ideas, researchers have recommended teachers to adopt guided inquiry teaching. It is thought that encouraging pupils' engagement in class activities will help them achieve more.

Academic achievement, in the words of Nurulafizan (2012), is what students have learned or have developed via education. Academic achievement is the extent of students' grasp of some knowledge about a subject or the proficiency in the application of such knowledge. There are a number of variables that have been found to influence students' academic success science, including instructional strategies and student sexual orientation (Akinwumi, 2017). It is believed that the teaching method adopted by the teacher could make or mar the achievement of students. In order to identify and suggest the most successful approach for teaching mathematics at the secondary school level, this study examined the effects of laboratory and inquiry teaching approaches on students' mathematical achievement.

The teaching method adopted by the teacher may have different effect on students' achievement with reference to their sex. Sex is the division of people into males and females, usually determined at birth based on the outward sex organs' appearance (Webster's New World College Dictionary, 2014). Achievement gaps between males and females are becoming a significant problem in education. Studies have shown that some teaching strategies are sex dependent, whereas others have shown the opposite. The findings of studies on how teaching approaches affect male and female pupils as a result do not always agree. Hence, another rationale for this study is to find out if laboratory and inquiry teaching methods are sex dependent with reference to students' achievement in Mathematics. In light of this, this study looked into how students' mathematics achievement in the Delta North Senatorial District was affected by laboratory and inquiry methods in order to recommend the most effective method for the teaching of Mathematics and also to ascertain if these teaching methods are sex dependent or not.

### **Statement of the Problem**

---

Examining the results of the WAEC Chief Examiner's reports on students' performance in mathematics from 2017 to 2021 showed that student achievement in Mathematics is below standard. Poor teaching techniques are just one of the causes of the poor performance of Mathematics students in the SSCE. The extensively employed traditional lecture approach in Nigerian secondary schools renders students inactive during instruction. For teaching to be successful, learners must actively participate. As a result, active teaching methods that encourage active participation from students during instruction may be a superior option to the conventional lecture method. Laboratory and inquiry teaching methods may be alternative methods since they pique and maintain students' interest while also allowing them to participate actively during teaching. Hence, the statement of the problem for this study is: Will the use of laboratory and inquiry teaching methods improve students' achievement in Mathematics more than the conventional lecture method? Again, will the use of laboratory and inquiry teaching methods improve Mathematics achievement scores among students of varying sexes differently?

**Purpose of the Study**

The purpose of the study was to investigate the effects of laboratory, inquiry and lecture teaching methods on students' achievement in Mathematics in Delta North Senatorial District. The study was specifically designed to ascertain:

1. the difference in the mean achievement scores among students taught Mathematics using laboratory, inquiry and lecture methods;
2. the effect of interaction of treatments and sex on students' achievement in Mathematics.

**Hypotheses**

The study was guided by three hypotheses:

1. There is no significant difference in the mean achievement scores among students taught Mathematics using laboratory, inquiry and lecture methods.
2. There is no significant effect of interaction of treatments and sex on students' achievement in Mathematics.

**Research Method**

The study used a quasi-experimental with a 3x2 factorial, pretest, posttest, planned variation design. Three teaching groups made up the design (laboratory, inquiry and lecture method groups) and two sex levels (male and female). The independent variable treatments are laboratory, inquiry and lecture methods, while the dependent variable is achievement in Mathematics. In this design, students in the three groups (laboratory, inquiry and lecture) were taught the same Mathematics concepts. The only difference between the three groups is the format of instruction. The inquiry teaching approach was used with the inquiry group, the lecture teaching approach with the lecture group, and the laboratory teaching approach with the laboratory group of students. Following that, the three techniques' effects on students' mathematics achievement were contrasted. 319 SSII Mathematics students were chosen as the sample size for this study using a stratified random sampling technique from six (6) public mixed secondary schools in the Delta North District. The Mathematics Achievement Test (MAT) was the tool utilised to collect data. The face validity of MAT was done by three experts comprised of one experienced Mathematics Teacher drawn from Baptist Medical Centre Staff Secondary School in Ethiopie East Local Government Area of Delta State, one Science Educator from Delta State University and an expert in Measurement and Evaluation from Delta State University Abraka. The Kuder-Richardson 21 formula was used to determine the reliability of MAT. MAT was administered to 30 students in Baptist Medical Centre Staff Secondary School in the Ethiopie East Local Government outside the sampled schools. The Kuder-Richardson formula 21 was applied to the data. Analysis produced a reliability coefficient value of 0.78. The treatment involved teaching students in laboratory, inquiry and lecture methods selected Mathematics concepts using laboratory method, inquiry method and lecture method. Pretests were administered before the treatment and posttest thereafter with MAT. ANCOVA was used to analyse the results.

**Results**

- There is no significant difference in the mean achievement scores among students taught Mathematics using laboratory, inquiry and lecture methods?

**Table 1: An Overview of the ANCOVA Comparison of the Mean Achievement Scores of Mathematics Students who Were Taught Using Laboratory, Inquiry and Lecture Methods**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9280.847 <sup>a</sup>	3	3093.616	24.119	.000
Intercept	79988.770	1	79988.770	623.636	.000
Pretest	366.520	1	366.520	2.858	.092
Method	8824.888	2	4412.444	34.402	.000
Error	40402.538	315	128.262		
Total	668500.000	319			
Corrected Total	49683.386	318			

As indicated in Table 1,  $F(2,315) = 34.402$ ,  $P(0.000) < 0.05$ , the posttest mean achievement scores of students who were taught mathematics using laboratory, inquiry, and lecture strategies varied significantly. As a result, the mean achievement ratings of

the students who learnt mathematics using laboratory, inquiry, and lecture strategies differed significantly. Scheffe's post-hoc comparison test was performed to assess the direction of the difference between the students in the three groups, as indicated in Table 2.

**Table 2: Summary of Scheffe's Post-hoc Test Comparison of Laboratory, Inquiry and Lecture Methods**

(I) Teaching methods	(J) Teaching methods	Mean Difference (I-J)	Std. Error	Sig. <sup>b</sup>	95% Confidence Interval for Difference <sup>b</sup>	
					Lower Bound	Upper Bound
Laboratory	Inquiry	9.467*	1.546	.000	6.425	12.509
	Lecture	12.623*	1.586	.000	9.503	15.744
Inquiry	Laboratory	-9.467*	1.546	.000	-12.509	-6.425
	Lecture	3.156*	1.537	.041	.131	6.181
Lecture	Laboratory	-12.623*	1.586	.000	-15.744	-9.503
	Inquiry	-3.156*	1.537	.041	-6.181	-.131

Table 2 demonstrates a significant difference in mean achievement scores between students who learned mathematics through laboratory and inquiry, favouring laboratory instruction; a significant difference in mean achievement scores between students who learned it through laboratory and lecture, favouring laboratory; and a significant difference in mean achievement scores between students who learned it through inquiry and laboratory instruction, favouring laboratory. Table 2 shows that the laboratory and the inquiry methods are more efficient than the lecture method.

- There is no significant effect of interaction of treatment (laboratory, inquiry and lecture method) and sex on students' achievement in Mathematics?

**Table 3: Summary of ANCOVA on the Interaction of Treatment and Sex on Achievement of Students**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10125.945 <sup>a</sup>	6	1687.657	13.311	.000
Intercept	79925.745	1	79925.745	630.395	.000
Pretest	346.367	1	346.367	2.732	.099
Method	9049.827	2	4524.913	35.689	.000
Sex	8.145	1	8.145	.064	.800
Method * Sex	842.642	2	421.321	3.323	.037
Error	39557.441	312	126.787		
Total	668500.000	319			
Corrected Total	49683.386	318			

The interaction between treatment and sex has a substantial impact on students' achievement in Mathematics, as shown in Table 3,  $F(2, 312) = 3.323$ ,  $P(0.037) < 0.05$ . As a result, there is a notable impact of the treatment (laboratory method) and sex interaction on students' achievement in Mathematics. This suggests that the students' sex may have an impact on how well they do in relation to the teaching approach.

## Discussion

The results of the study showed that students who learned mathematics using laboratory, inquiry, and lecture approaches had significantly different mean academic achievement ratings. According to the Scheffe's post-hoc test, students who were taught mathematics using the laboratory approach performed best, followed inquiry method students, and lecture method students performed poorest. It's possible that the lecture method of teaching, in which teachers impart their knowledge to their students, has anything to do with the poor achievement scores reported among those students. According to Ajaja (2016), this teaching approach suggests that students play a primarily passive role in the learning process. However, using laboratory and inquiry approaches encourages students to actively participate in their education. This could be the reason why students who were taught utilising laboratory and inquiry approaches had higher achievement results. This discovery is in line with past research's findings. This result is consistent with that of Uzezi and Zainab (2017), who found that guided-inquiry laboratory experiments had a significant impact on students' academic achievement compared to the traditional lecture method because they motivated the students, and this was reflected favourably in their mean achievement scores in chemistry. This finding is in line with that of Alake (2015), who claimed that students exposed to the laboratory instructional strategy significantly outperformed their counterparts subjected to the lecture mode of instruction in terms of performance, retention of the concepts learned, and attitude towards geometry.

A strong interaction impact between teaching strategy and sex on students' academic achievement in mathematics was once again found by the study. This suggests that student sex has an impact on how well students do in relation to the teaching strategy. The laboratory method has a higher effect on students' academic ability in mathematics when the students' sex is taken into account. One possible explanation that could suffice is that the students' interest may have been aroused and sustained in a particular sex than

the other through the use of laboratory method. The laboratory technique had an effect on the mean accomplishment scores of male students more than their female counterparts. This result contradicts Bajon's (2015) assertion that there was no significant interaction between the type of laboratory activity and gender that affected students' mean accomplishment score.

### Conclusion

The study concludes that laboratory and inquiry methods improve students' academic achievement in Mathematics more than the lecture method. Nevertheless, laboratory method enhances students' academic achievement more than inquiry method. The study, also, concludes that teaching method (laboratory method) did combine with students' sex to influence students' achievement in Mathematics.

### Recommendations

1. Mathematical teachers should use laboratory and inquiry approaches to teach the subject at the secondary school level. These teaching-learning strategies encourage students' active participation and knowledge acquisition, which will lessen the abstraction associated with mathematical topics.
2. To ensure that all mathematical concepts are easily understood, mathematics teachers should make sure that they are all practically shown.

### REFERENCES

- Ajaja, O. P. (2016). *Teaching methods across disciplines (2<sup>nd</sup> ed.)*. Ibadan: Bomn Prints Publishers.
- Akinwumi, J. O. (2017). Effects of gender and school location on the Ekiti State secondary school students' achievement in reading comprehension in English language. *Journal of Education and Practice*, 8(5), 50-55.
- Alake, E. (2015). Efficacy of laboratory instructional strategy on students' geometry performance, retention and attitude among junior secondary schools of Kaduna State, Nigeria (Unpublished Master Dissertation). Ahmadu Bello University, ABU, Zaria.
- Ali, A. (2014). The effect of inquiry-based learning method on students' academic achievement in science course. *Universal Journal of Educational Research*, 2(1), 37-41.
- Anibueze, C. O. (2015). Improvisation of instructional materials for the functional teaching/learning of mathematics in Enugu North LGA in the 21<sup>st</sup> century. *IMT International Journal of the Arts and Sciences*, 1(1), 26-37.
- Bajon, R. H. (2015). Effect of mode laboratory work on senior secondary school students' achievement in biology in Jalingo Local Government Area of Taraba State (Unpublished Masters Project). University of Nigeria, Nsukka.
- Chibabi, A. A., Umoru, S. E., Onah, D. O., & Itodo, E. E. (2018). Effect of laboratory method on students' achievement and retention in senior secondary schools biology in Kogi East Senatorial Zone. *IOSR Journal of Research and Method in Education (IOSR-JRME)*, 8(6), 31-39.
- Chukwudebem, A. (2019). Effects of guided inquiry instructional strategy and cognitive style on students' academic achievement in Physics in Delta North Senatorial District (Unpublished Master Dissertation). Delta State University, Abraka.
- Ebiguvwere, A. I. (2018). Effects of guided inquiry instructional strategy on students' achievement and interest in senior secondary school chemistry in Delta North Senatorial District (Unpublished Master Dissertation). Delta State University, Abraka.
- Federal Ministry of Education. (2005). *National curriculum for senior secondary schools' science*. Lagos: NERDC Press.
- Federal Republic of Nigeria. (2013). *National policy on education (Revised ed)*; Lagos: NERDC Press.
- Joshi, S. R. (2018). *Teaching of Science*. New Delhi: APH Publishing Cooperation.
- Kelubia, D. I. (2021). Effects of inquiry-based and demonstration teaching methods on students' achievement in basic technology in Delta North Senatorial District (Unpublished Master Dissertation). Delta State University, Abraka.
- Millar, R. (2014). *The role of practical work in the teaching and learning of science*. Paper presented at the "High School Science Laboratories: Role and Vision" Meeting, 27-29, April, 2014.
- Ng'ethe, M. A. (2016). *Effects of practical work on students' achievements in Physics at secondary school level in Murang'a East Sub-County, Kenya*. Retrieved 2<sup>nd</sup> August, 2022 from <https://ir-library.ku.ac.ke/bitstream/handle/123456789/11820/effects%20of%20practical%20work%20on%20students%20%20achievements.pdf?sequence=5>.
- Nurulafizan, C. (2012). *The concept of academic achievement*. Retrieved 2<sup>nd</sup> August, 2022 from <http://edu725nurule.blogspot.com/2012/11/22-concept-of-academic-achievement.html>.
- Osborne, T. (2012). Science without literacy: A ship without a sail. *Cambridge Journal of Education*, 32(2), 203-218.
- Sandoval, W. A., & Reiser, B. J. (2014). Explanation-driven inquiry: Integrating conceptual and epistemic scaffolds for scientific inquiry. *Science Education*, 88, 342-375.
- Suleiman, Y., & Hammed, A. (2019). Perceived causes of students' failure in mathematics in Kwara State junior secondary schools: Implication for educational managers. *International Journal of Educational Studies in Mathematics*, 6(1), 19-33.
- WAEC Chief Examiner's report. (2017-2021). *WAEC Chief Examiner's report on mathematics*. Retrieved 1<sup>st</sup> August, 2022 from <https://waeconline.org.ng/e-learning/Mathematics/mathsmain.html>.
- Webster's New World College Dictionary (2014). *Definition of sex*. USA: Houghton Mifflin Harcourt Publishing Company.
-