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## INQUIRY-BASED LEARNING AND SENIOR SECONDARY STUDENTS' PERFORMANCE IN THE CONCEPT OF MENSURATION IN MINNA EDUCATIONAL ZONE, NIGER STATE, NIGERIA

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### Abstract

This study aimed to assess the impact of inquiry-based Learning compared to conventional methods on students' mathematics performance in mensuration concepts. The analysis utilized a quasi-experimental design with a control and experimental group involving pre-test and post-test measures. The target population consisted of 12,430 students from Minna Education Zone, with a sample size of 95 SSII students randomly selected from two schools. Data collection involved three instruments: The Mathematics Performance Test (M.P.T.), a Lesson Model for the experimental group, and a Lesson Model for the control group. The M.P.T. was validated by experts and demonstrated good reliability. The result indicated that students exposed to inquiry-based Learning performed significantly better than those using conventional methods. There is no significant difference found in gender performance in the experimental group. Based on these results, it is recommended, among others, that teaching mathematics incorporate active-based methods like inquiry-based Learning.

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**Keywords:** Conventional Method, Inquiry-based Learning, Students' Performance, Mensuration

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### Introduction

Mathematics is a crucial subject involving problem-solving activities involving the study of numbers, shapes, and spaces. It is the language of science and technology, contributing to scientific and technological advancements and overall human development. In Nigeria, mathematics is taught as a core subject at primary and secondary education levels due to its significance across various domains (Aliyu & Ahmad, 2021). At the secondary school level in Nigeria, mathematics is divided into seven themes, one of which is mensuration. Mensuration measures geometric forms and their parameters, such as length, volume, surface area, and lateral surface area. It serves as a foundational component of engineering and technical graphics. However, research suggests that students often need help with conceptual understanding and skills related to this branch of mathematics, and many secondary school students need to be adequately prepared for the mensuration theme (Aliyu & Ahmad, 2021). Despite the compulsory nature of mathematics and its central role in secondary education in Nigeria, the performance in mathematics, particularly in mensuration, has consistently been poor for years. External examination results reveal that only a tiny percentage of students achieved credit-level passes (grades C6-A1) in mathematics over the years, hindering their admission to tertiary institutions, as credit-level passes are prerequisites for admission to science, social science, technical, and engineering courses (Inekwe, 2019). This persistent poor performance in mathematics, especially in mensuration, has raised concerns among educators and researchers (Inekwe, 2019; Aliyu & Ahmad, 2021).

The instructional methods employed by mathematics teachers in Nigerian secondary schools have been identified as contributing factors to students' poor performance. The traditional teaching approach is often teacher-centred, relying on verbal presentations and generalizations of facts. Although suitable for handling large class sizes and covering extensive content, this method has limitations. It fails to promote meaningful Learning, critical thinking, and creativity and tends to favour academically advantaged students, neglecting those who are disadvantaged (Khalid et al., 2019). Studies have shown that this teaching method does not effectively engage students or foster their interest in mathematics (Ali, 2014; Kessy & Irene, 2021). Therefore, there is a need to explore alternative teaching methods to improve performance in mathematics, particularly in mensuration. It is crucial to shift from a

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teacher-centred approach to a learner-centred approach, where mathematics is meaningful, enjoyable, and accessible to students (Jamilu, 2013). Various instructional methods, such as scaffolding, problem-solving, cooperative Learning, inquiry-based Learning, and peer tutoring, have been recommended for effective teaching and Learning of Mathematics (Ahmad et al., 2022). In light of these considerations, the researchers have adopted inquiry-based Learning and conventional teaching methods for this study.

Inquiry-Based Learning (IBL) is an instructional approach that empowers learners to explore and discover mathematical concepts and tasks actively. In this method, the teacher presents the curriculum content and provides opportunities for students to search for facts and ideas in mathematics (Odupe & Opeisa, 2019). Through IBL, learners engage in a process of inquiry and discovery, which fosters a deep understanding of mathematical concepts and encourages active participation in the learning process. Students are encouraged to observe, question, measure, classify, predict, and communicate their findings. This approach is particularly suitable for senior secondary school (S.S.S.) classes because it is a constructivist approach to teaching in which learners are encouraged to discover principles in mathematics by themselves through inquiry-based learning. The IBL is very advantageous because students build their knowledge and it inculcates manipulative skills, and retention, and transfer of knowledge are facilitated as pointed out by Ahmad et al. (2022). The IBL can take different forms, such as structured inquiry, where the teacher provides problem-solving tasks and the necessary procedures and materials. This type of IBL is used to teach specific concepts or skills and can lead to open inquiry, where learners formulate their problems to investigate. An example of a structured inquiry learning cycle model is based on Piaget's theory of cognitive Learning (Ali, 2014). Piaget's theory is the theoretical framework for this learning approach, emphasizing that knowledge acquisition is driven by the individual's efforts to explore and interpret the environment.

According to Khalid et al. (2021), IBL provides students with opportunities to work collaboratively with peers, develop communication skills, and construct their knowledge, leading to improved performance, retention, and engagement in the learning process. In this method, the teacher assumes the role of a guide rather than a knowledge provider. Students must integrate skills, concepts, and knowledge to solve real-life problems, demonstrating a deep understanding of mathematics and engaging in critical thinking. IBL also helps build students' confidence in mathematics and develops various intellectual skills, such as analysis and exploration.

In summary, the use of Inquiry-Based Learning in mathematics and other science subjects offers several benefits, including:

- Nurtures passions and talents.
- Increases motivation and engagement.
- Emphasizes the importance of asking questions.
- Gives learners ownership of knowledge.

The study implemented Inquiry-Based Learning (IBL) using the 5E instructional model: Engagement, Exploration, Explanation, Elaboration, and Evaluation. Previous research has shown that IBL positively affects students' academic achievement (Jamilu, 2013; Ali, 2014; Odupe & Opeisa, 2019; Khalid et al., 2019; Kessy & Irene, 2021). Additionally, investigating gender differences in the Learning of science subjects, including mathematics, remains vital in mathematics education (Jamilu, 2013; Odupe & Opeisa, 2019; Khalid et al. 2021). There have been inconsistent findings regarding gender differences and mathematics achievement, with various studies conducted in recent years. In light of these considerations, the present study aims to compare the effects of Inquiry-Based Learning and Conventional Methods on the performance of mathematics students in mensuration.

### Statement of the Problem

The persistent mass failure and poor performance of students in both external and internal examinations in Nigeria today is a serious and challenging issue for students, teachers, parents and mathematics educators. Khalid et al. (2021) reported that students found mensuration concepts in mathematics difficult to understand and failed questions in it. Research evidence by Khalid et al. (2021), and Aliyu and Ahmad (2021) have identified instructional methods and strategies utilized by mathematics teachers in their classrooms as one of the root causes of undesirable massive failure and poor performance in mathematics, especially mensuration concepts. Furthermore, the Chief Examiner of the West Africa Examination Council (WAEC) in reports from 2014 to 2018, attributed poor performance to conventional teaching methods and a lack of instructional aids.

Given this persistent issue, mathematics teachers must explore innovative teaching methods to improve student's performance and enhance their ability to retain what they have learned. By seeking new approaches to teaching mathematics, teachers can create a more engaging and effective learning environment that supports students in achieving better outcomes in mensuration and beyond. Therefore, the study is to seek out whether the implementation of inquiry-based learning brings out better performance in mathematics, especially mensuration concepts.

### Objectives of the Study

The study aimed to compare the effects of Inquiry-Based Learning and Conventional Methods on mathematics students' mensuration performance. Specifically, the present study sought to achieve the following objectives:

1. Examine the impact of inquiry-based Learning and conventional methods on the performance of senior secondary students when taught mensuration concepts in mathematics.
2. Determine the effect of inquiry-based Learning on the performance of male and female senior secondary students when taught mensuration concepts in mathematics.

### Research Questions

The following research questions guided the study:

1. Is there a significant difference in the performance of students exposed to inquiry-based Learning compared to those exposed to the conventional method when being taught mensuration concepts in mathematics?
2. Is there a significant difference in the performance of male and female students exposed to inquiry-based Learning when taught mensuration concepts in mathematics?

### Research Hypotheses

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

H<sub>01</sub>: There is no significant difference in the performance of students exposed to inquiry-based Learning compared to those exposed to the conventional method when being taught mensuration concepts in mathematics.

H<sub>02</sub>: There is no significant difference in the performance of male and female students exposed to inquiry-based Learning when taught mensuration concepts in mathematics.

### Methodology

The present study utilized a quasi-experimental design consisting of experimental and control groups. The experimental group received instruction using a lesson model designed through Inquiry-Based Learning. In contrast, the control group was taught using a lesson model based on the Conventional Method (CM). Before the treatment, a pre-test was administered to both groups to assess their initial knowledge and ensure equivalence. A post-test was subsequently administered to evaluate the academic performance of both groups. The target population for this study consisted of 12,430 senior secondary school two (SSII) students in Minna Educational Zone, including 6,987 males and 5,443 females. The sample size comprised 95 SSII students, with 43 students (24 males, 19 females) in the experimental group and 52 students (28 males, 24 females) in the control group. The sample size of 95 students was determined based on the central limit theory, which recommends an appropriate sample size of  $N=30$  for research studies (Sambo, 2008). The sample was randomly selected from two schools using a simple random sampling technique. Three research instruments were developed for the study. The first instrument was a pre-test titled Mensuration Performance Test (MPT), which assessed the initial performance of the two groups and was drawn from the mathematics textbook used in SS1 classes. It consisted of 20 multiple-choice questions. The second instrument was the post-test (MPT2), which evaluated the student's academic performance after the treatment. It also comprised 20 multiple-choice questions. Both instruments were validated by experts from the Department of Mathematics at the College of Education, Minna, and the Department of Science Education at A.B.U. Zaria. The reliability of the instruments was established through test-retest, with a reliability coefficient of 0.75 for MPT1 and 0.74 for MPT2, indicating high positive correlations between the instruments.

Data collected from the study were analyzed using mean, standard deviation, and mean difference for research questions and t-test for the null hypotheses. The study employed the 5E instructional lesson model in implementing IBL for the experimental group. The model consisted of five consecutive stages: engagement, exploration, explanation, elaboration, and evaluation. In the engagement stage, the teacher assessed students' prior knowledge

and stimulated their interest and curiosity. The exploration stage involved exposing students to fieldwork, experiments, simulations, or prepared documents to achieve the stated objectives. In the explanation stage, students presented their findings, and the teacher provided assistance and explained any missed vocabulary. The elaboration stage involved addressing new issues and relating them to previously learned concepts. Finally, in the evaluation stage, the teacher assessed the learners' achievement through oral or written tests based on the topics covered.

## Results

**Research Question One:** Is there a significant difference in the performance of students exposed to inquiry-based Learning compared to those exposed to the conventional method when being taught mensuration concepts in mathematics? Descriptive statistics were used to answer the stated question, and the result is provided in Table 2.

**Table 1: Mean and Standard Deviation of Experimental and Control Groups in post-test**

Groups	N	Mean	SD	Mean Difference
Experimental	43	50.82	14.21	17.23
Control	52	33.59	12.53	

The experimental group's mean score and standard deviation were 50.82 and 14.21, respectively, while the control group had a mean score of 33.59 and a standard deviation of 12.53. The calculated mean difference of 17.23 in favour of the experimental group indicates a significant difference in performance. Inferential statistics, such as a t-test, can be applied to determine the statistical significance of this difference. By analyzing both groups' means and standard deviations, researchers can evaluate whether the observed difference is likely due to the implementation of inquiry-based Learning or if it could have occurred by chance alone.

**Hypothesis One:** There is no significant difference in the performance of students exposed to inquiry-based Learning compared to those exposed to the conventional method when being taught mensuration concepts in mathematics. The post-test scores are subjected to t-test analysis to test the stated hypothesis. The details are provided in Table 2.

**Table 2: T-test Analysis of Experimental and Control Groups in Post-test**

Groups	N	Mean	SD	Df	t-value	p-value	Decision
Experimental	43	50.82	14.21	93	5.92	.001	Sign.
Control	52	33.59	12.53				

The results presented in Table 3 indicate that the p-value was .001, and the t-value was 5.92. With a p-value lower than the predetermined alpha value, we can conclude that the null hypothesis is rejected. This signifies a significant difference between the performance of the experimental and control groups in the post-test scores. The findings establish that inquiry-based Learning enhances students' performance in the mensuration concept of mathematics more effectively than the conventional method.

**Research Question Two:** Is there a significant difference in the performance of male and female students exposed to inquiry-based Learning when taught mensuration concepts in mathematics? The data obtained on the gender performance of S.S. Two students taught mensuration concepts in mathematics using Inquiry-based Learning is provided in Table 3.

**Table 3: Mean and Standard Deviation on gender Performance of Experiment Group**

Groups	N	Mean	SD	Mean Difference
Male	24	41.21	15.13	0.82
Female	19	40.39	13.04	

To determine if the closeness in mean scores between male and female students is statistically significant, inferential statistics were used to test the null hypothesis. In Table 3, the mean score for male students was reported as 41.21, with a standard deviation of 15.13. On the other hand, female students had a mean score of 40.39 and a standard deviation of 13.04. The mean difference between the two groups was calculated as 0.82, indicating a relatively small difference. Appropriate inferential statistical tests can be applied to assess the statistical significance of this closeness to determine if the observed mean difference could have occurred by chance alone or if it is statistically significant.

**Hypothesis Two:** There is no significant difference in the performance of male and female students exposed to inquiry-based Learning when taught mensuration concepts in mathematics. To test this null hypothesis, the post-test scores of male and female students in the experimental group were compared and subjected to t-test statistics. The result obtained is presented in Table 4.

**Table 4: T-test Analysis of Males and Females of the Experimental Group in the Post-test**

Gender	N	Mean	SD	Df	t-test	p-value	Decision
Male	24	41.21	15.13	41	0.21	0.84	Not sign
Female	19	40.39	13.04				

According to the results presented in Table 4, the obtained p-value was 0.84, more significant than the predetermined alpha level of 0.05. Based on this result, we retain the null hypothesis. Therefore, there is no significant difference between male and female students exposed to Inquiry-Based Learning performance scores when taught the mensuration concept of mathematics. The findings suggest that the impact of gender on performance in this context is not statistically significant.

### Discussion

The results of this study support the findings of previous research conducted by Ali (2014), Kessy and Irene (2019), Khalid et al. (2021), Jamilu (2013), and Odupe and OPeisa (2019), which all suggest that Inquiry-Based Learning can lead to improved performance in science subjects, particularly mathematics. The method is merit because learners build their knowledge since the method is the learners' Centre and it inculcates manipulative skills, retention, recall and transfer of knowledge. The present study confirms that students who were exposed to IBL while taught mensuration concepts in mathematics achieved better academic performance than those taught using conventional methods.

Furthermore, the study found no significant difference in the academic performance between male and female students when taught using IBL in the mensuration concept of mathematics. This finding aligns with the results reported by Jamilu (2013), Odupe and OPeisa (2019), and Khalid et al. (2021), IBL is an inclusive instructional approach that can benefit both male and female students equally. The results also indicate that the use of IBL in teaching mensuration concepts in mathematics was well-received by students. IBL's friendly and engaging nature allowed students to take ownership of their knowledge, collaborate with peers, and develop communication skills. These features of IBLs contributed to an effective classroom instruction environment, leading to better performance in various tasks. This study adds to the existing body of evidence supporting IBL's effectiveness in improving

student mathematics performance and highlights its inclusivity and positive impact on student motivation and engagement.

### Conclusion

Based on the findings of this study, we can conclude that Inquiry-Based Learning had a significant impact on students' performance in the mensuration concept of mathematics compared to the Conventional Method (CM). The results suggest that IBL is a more effective instructional approach for teaching this topic. Furthermore, the study revealed that IBL promotes equality in the performance of male and female students. Gender did not have a significant influence on the effectiveness of IBL in improving student performance. This indicates that IBL is a suitable teaching method for science subjects, particularly mathematics, as it can benefit all students regardless of gender. The study concludes that IBL is a highly effective approach for teaching the mensuration concept of mathematics, surpassing the conventional method. Additionally, IBL promotes equality in performance between male and female students, making it a suitable instructional approach for teaching science subjects, especially mathematics.

### Recommendations

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

1. Mathematics teachers may be advised to use Inquiry-Based Learning in classroom instruction at the senior secondary school level. The method has proved to be a successful method for improving students' performance and enhancing the teaching and Learning of mathematics.
2. Equal opportunity should be given to both female and male students to actively participate in the classroom instruction. This active participation in the learning process may be strengthened by moving learners' passive mode to an active mode as improved classroom conditions.
3. Mathematics teachers should be provided with opportunities for professional development in Inquiry-Based Learning. Conferences, seminars, and in-service training programs should be organized to familiarize teachers with the principles and practices of IBL. This will enable them to effectively implement IBL in their classrooms and adapt it to the specific needs of their students.
4. Mathematics curriculum planners should consider incorporating Inquiry-Based Learning as a recommended teaching method in mathematics and related science subjects in secondary schools. By officially recognizing and adopting I.B.L. in the curriculum, educational authorities can ensure its systematic implementation across schools. This would provide students with a consistent and coherent learning experience and help them develop critical thinking, problem-solving, and collaborative skills.

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