Faculty of Natural and Applied Sciences Journal of Mathematics and Science Education
Print ISSN: 2814-0885 e-ISSN: 2814-0931
www.fnasjournals.com
Volume 7; Issue 2; December 2025; Page No. 45-53.
DOI: https://doi.org/10.63561/fnas-jmse.v7i2.1089

Comparative Effects of Laboratory-Based and Discussion-Based Instruction on Junior Secondary Students' Performance and Retention in Plane Geometry

[*]Unamba, J.O.
Department of Curriculum Studies and Instructional Technology, Ignatius Ajuru University of Education, Port Harcourt, Nigeria

[*]Corresponding author email: janechrisunamba@gmail.com

Abstract
This study aimed to investigate the Comparative Effects of Laboratory-Based and discussion-based instruction on junior secondary students' performance and Retention in Plane Geometry. Two research questions, two null hypotheses, and two aims and objectives made up the investigation. The research was quasi-experimental in nature. For the study, intact classrooms were employed. In Rivers State, Nigeria, a sample of 119 public junior secondary class two students was selected from a total of 6,132 students. Data collection involved the use of the Plane Geometry Achievement Test (PGAT). With validation, PGAT's reliability index was 0.81. While the control group received education using a discussion-based approach, the experimental group received practical laboratory-based instruction in plane geometry. Analyses were conducted using the mean, standard deviation, and Analysis of Covariance (ANCOVA) at the 0.05 level of significance. For testing hypotheses, a significant level of 0.05 was employed. The results demonstrated that students who received instruction through laboratory-based based performed better and retained information, with a mean gain performance of 22.95, SD=13.58, than their counterparts in the control group, who had a mean gain performance of 10.74, SD=7.35, which was statistically different. It was suggested that teachers should employ laboratory-based instruction to teach mathematical principles and practical plane geometry.

Keywords: Laboratory-Based Instruction, Plane Geometry, Mathematics Laboratory, Students' Performance, Discussion-Based Instruction

Introduction

Mathematics is considered by many to be as very important subject, because of its usage in day-to-day transactions. Mathematics is the science of numbers, quantity and space; therefore, everything is mathematically in nature. Every nation's meaningful scientific and technological development depends on having a solid understanding of mathematics. It is a crucial tool for the study of technology, science, and the humanities. Every day, we apply mathematical ideas to real-world circumstances to address issues in math, science, and technology. Mathematics serves as the cornerstone on which engineering, science, technology, and other professions are created. A person's ability to think rationally, solve problems analytically and creatively, pay close attention, accurately, and clearly is also enhanced by studying mathematics. This demonstrates how important mathematics is to someone's entire meaningful growth and how important it is (Kakraba, 2020). It is one of the compulsory subjects students must credit in order to be admitted to the higher institution. The Nigerian Ministry of Education made mathematics a required subject at the basic and secondary levels of instruction because of its significance for the growth of the country. In addition to its significance, it is noted that mathematics is one of the subjects in schools that is among the worst taught, most despised, and least understood. However, it seems like student performance in the subject has been declining for a while. The annual external exams, such as the Basic Examination Certificate Examination (BECE) and the National Examination Council Basic Education Certificate

Cite this article as:
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Examination (Junior NECO), among others, also represent the students' mathematical performance's penitent state. No matter how the learners are instructed, it is thought that if the foundation is weak, all of the effort may be for nought.

Unfortunately, it has been found that students generally perform poorly in mathematics. Without effective control, this situation cannot be allowed to keep getting worse. As students go up the grades, their poor math performance seems to get worse. This horrible situation has been caused by a variety of circumstances. This includes early teaching, the use of the appropriate teaching resource, excessive anxiety, low self-efficacy, and a lack of student interest or desire in learning mathematics, among other things. Students' poor arithmetic performance is also a result of a lack of qualified teachers, a lack of a mathematics laboratory, and a lack of interesting and innovative teaching methods. According to Wonu and Arokoyu (2016), These factors led to the students-centred learning approach, where learning is placed in the hands of the learners and the teacher acts as a guide to the learner. The main goal of learning is to convey knowledge and skills, not to recall or replicate information that was passively absorbed. Instead, it is to involve students creatively and actively in cooperative or autonomous learning. In this, learners are actively engaged and they recall facts easily because they are fully involved. This is an era of media-driven innovations, and mathematics teaching must devise ways of teaching concepts in an interactive way that develops the student's three domains of cognitive, psychomotor and affective. The construction of a mathematics lab was required because it was necessary to engage students in critical-thinking activities to develop their capacity for independent thought and improve their performance in mathematics. Eliminating the dogmatic methods of teaching mathematics is one of the goals of the nation's new mathematics curriculum. Utilising a proactive approach in a math lab is one such option.

According to Odogwu (2015), the mathematics laboratory is a setting where students can study and explore mathematical concepts as well as check mathematical facts and theorems through a variety of activities employing various materials. The teacher or the students might engage in these activities to explore, learn, pique interest in, and cultivate a positive attitude toward mathematics. A mathematics laboratory, according to Maheshwari (2018), is a room equipped with a range of materials and teaching/learning instruments that are essential for giving students the knowledge they need through relevant, substantial, and useful activities. The materials in the math lab are meant to be used by the students both alone and in partnership with their teacher in order to investigate, learn about, and develop an interest in the field of mathematics. The exercises in the math lab should be interesting to a range of people with different ages and mathematical prowess. The teacher or the students can engage in these activities to explore the world of mathematics, learn about it, discover it, and get interested in it. A mathematics laboratory can significantly aid in the understanding of mathematical concepts, even though mathematics is not an experimental discipline like physics or chemistry. According to Odili (2006), a mathematics laboratory is a space specially equipped for math learning that is located in the same building as regular math classes. It can also be a small area of a regular classroom with tables and equipment, or it can be a collection of manipulatives for students. The mathematics lab is a place to engage in casual investigation of mathematics. Anyone can create difficulties there and struggle to find solutions. It is a place where new mathematical activities can be explored and created. Students' understanding often goes beyond the curriculum in the math lab. Students get the chance to learn mathematics by doing it in the mathematics laboratory. Many of the activities pose a challenge or a problem that could lead to more difficulties or issues. The exercises support students' ability to manipulate, reason, and imagine. They offer the chance to formulate hypotheses, test them, and extrapolate previously noticed trends. They provide a setting in which students can try to support their hypotheses. Odogwu (2015) opined that the purpose of the mathematics laboratory in the teaching and learning of mathematics includes, among others, the following;

1. It provides a focal point within the school for mathematical knowledge and inspiration.
2. It provides facilities for incorporating experiments and practices in the learning of mathematics and its applications.
3. It is a centre for mathematical information. The information to be provided will include models, diagrams, visual representations of mathematical concepts CD, games and any other material that will be useful in the teaching and learning of mathematics
4. It provides a setting for developing mathematical cognitive and psychomotor abilities, such as the capacity to construct, measure, arrange, observe, classify, understand, and generalise.

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As kids enter high school, geometry becomes a math concept that many find more challenging. By virtue of its very nature, geometry calls for critical thinking, and instructors who like teaching mathematics employ teaching techniques to boost involvement and foster independent thought among their pupils (Carney et al., 2016; quoted in Tamashwar, 2020). People who study geometry become more perceptive of their surroundings. Everything in life has to do with shapes ranging from plants, furniture, building, constructions, graphic design, arts, medical equipment, football pitch, technology etc. and for the students to understand the application of geometry theories into real life situations, they are made to design their shapes and use it in calculations for deeper understanding of the concept using laboratory strategy since learning lies in the hands of the learners in this 21st century method of teaching. Such geometric solid shapes are: cubes, triangles, rectangle, squares, circles, cuboids, cylinder, prisms and cones, etc. The laboratory-based methodology was formed on the principles of constructionist learning theory by Seymour Papert in the year 1980 and social learning theory by Albert Bandura in the year 1977. The core notion is that a student-centred classroom fosters the development of higher-level thinking abilities, topic mastery, and participation in group decision-making in a democratic classroom environment. The value that laboratory-based approach teachers hold is that they are facilitators of student learning and discovery as they create collaborative, student-centred learning settings, as opposed to depending on lectures and other passive activities (Nhem, 2015, cited in Richard, 2016).

According to Seymour Papert, constructionist learning involves students building mental models to help them comprehend the environment. Constructionism promotes student-centred, inquiry-based learning in which students build on what they already know to learn new things. Through their participation in project-based learning, students gain knowledge by connecting various concepts and bodies of knowledge, assisted by the teacher through coaching rather than through lectures or detailed instructions. Additionally, constructionism maintains that learning occurs most successfully when individuals actively create concrete things in the real world. In this way, constructionism relies on Jean Piaget's constructivist epistemological theory and is related to experiential learning. Papert talked about kids writing instructional programs in the Logo programming language. He compared their education to living in a "mathland," where picking up mathematical concepts naturally comes as second nature as studying French while residing in France.

Students who learn constructively come to their own conclusions through imaginative experimentation and the creation of social things. Constructivism is an ideology that asserts that knowledge is created by students as opposed to being only passively absorbed. When people interact with the world and reflect on it, they create their own models of it that incorporate new information as well as what they already know. The constructionist learning theory was developed by Seymour Papert. Piaget's experimental learning theory influenced him and holds that youngsters build new information through the use of manipulative and physical items, such as blocks, beads, shapes, and robotics kits. Instead of playing an instructional role, the constructionist teacher adopts a mediational one. By enabling them to comprehend problems in a hands-on manner, problems that were previously taught "at" students are now taught "to" students. The teacher's job is to coach pupils toward achieving their own objectives, not to deliver lectures. A constructionist approach called laboratory-based instruction allows students to learn about a subject by presenting them with a variety of challenges and asking them to build their understanding of the subject through these difficulties. Because students attempt to answer the issues in a variety of ways, activating their imaginations on generated or envisioned shapes, this type of learning can be particularly effective in geometry and mathematics programs.

Further research were done by other researchers on similar topics in different locations: George and Edekor (2022) examined junior secondary students' proficiency and retention in plane geometry in Rivers State. The purpose of the study was to examine the effects of mathematics laboratory-based instruction on the performance and retention of junior secondary pupils in plane geometry. The study has four research questions and four null hypotheses. The study had a quasi-experimental design with sample of 122 public junior secondary class two pupils from the Port Harcourt Local Government Area of Rivers State, Nigeria, chosen from a population of 2,371 students. Plane Geometry Achievement Test (PGAT) was used to collect data. PGAT was validated and had a reliability score of 0.85. The z-test statistic, mean, and standard deviation were used in the analysis. A significant level of 0.05 was used to test hypotheses. According to the findings, there was a statistically significant difference in performance and retention between students in the laboratory-based instruction group and those in the control group. In Rivers State, Onwioduokit (2014) used collaborative and demonstration-based research methods to examine students'

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conceptions of measurement in the mathematics lab. The study examined how group projects and demonstrations in math laboratories in Rivers State could help students grasp mensuration in senior secondary school mathematics. It was chosen to utilize a 4x2 factorial quasi experimental design with a pre-test and post-test control group. The population of the study consisted of eight hundred (800) senior secondary two (SS2) students from six (6) government secondary schools in the Okrika Local Government Area. The study involved a selected sample of 105 students who satisfied specified criteria. Data were gathered using a tool created by the researcher called the Test on Understanding of the Concept of Mensuration (TOUCM). The reliability coefficient for TOUCM was estimated to be 0.86. Two hypotheses and two research questions served as the foundation for the examination. Mean and standard deviation were utilized to answer the study's questions, and analysis of covariance (ANCOVA) was carried out to assess the hypotheses. The findings demonstrated that students who were taught mathematics through laboratory-based instruction and demonstration outperformed all of their peers in terms of understanding concepts of mensuration. Abel (2021) investigated how a mathematics laboratory instructional technique affected the proficiency of junior secondary pupils in plane geometry. The study looked at how junior secondary students' proficiency in plane geometry was affected by the mathematics laboratory instructional method in the Obio/Akpor Local Government Area of Rivers State. The study used a quasi-experimental, non-randomized, intact class, non-equivalent pretest and posttest design. Two (2) schools were selected at random from a total of fourteen (14) schools using a straightforward sampling procedure. There were 8,431 JSS2 students in the study population, and 96 students made up the sample. Two research questions and two hypotheses formed the basis of the study. The Mathematics Performance Test (MPT), which was validated and demonstrated to have a 0.82 reliability grade, was used to collect the data. The mean and standard deviation were used to respond to the study questions, and an ANCOVA was carried out to assess the hypotheses at the 0.05 level. The results of the study demonstrated that there was a substantial difference in the students' performance when compared to students who were taught the properties of plane forms using the traditional technique and a mathematics laboratory teaching style. Salami (2022) inquiry focuses on the geometrical math performance of senior secondary school students in Ekiti State. The purpose of the study was to examine the effects of a mathematical laboratory teaching method on students' geometrical performance in a sample of selected secondary schools in Ekiti State, Nigeria. Pre-test, post-test, and control group quasi-experimental designs were employed in the study. The population for the study consisted of 2,483 SS II students, while the sample for the study consisted of 200 SS II students randomly selected from four secondary schools in the Moba Local Government Area of Ekiti State. The Geometric Achievement Test (GAT) was the tool utilized to gather the study's data. The test-retest method of assessing reliability was used to evaluate the instrument's reliability. In Kogi State, Nigeria, senior secondary school students were studied for their performance and retention in trigonometry using laboratory procedures by Dharrriyat and Arivi (2020) the study investigated the effects of laboratory teaching techniques on the performance and retention of trigonometry among senior secondary school students (SSS2) using a quasi-experimental research design. 117 individuals were randomly selected from the 4,753 study participants to comprise the sample. There was one experimental group and one control group. The experimental group employed a laboratory instructional strategy approach, whereas the control group employed a conventional teaching strategy approach. Each group received therapy for six (6) weeks. To assess the students' performance and retention, pre- and post-tests were administered at the beginning and conclusion of the lesson, respectively. The T test was used to examine the research hypotheses. At the 0.05 level of significance. According to the study's findings, senior secondary schools can learn trigonometry and other areas of mathematics more effectively by implementing laboratory teaching strategies. A study on the impact of implementing a mathematics laboratory in the classroom on students' arithmetic achievement was also undertaken by Okigbo and Osuafor in 2008, the study looked into how students' performance in junior secondary school mathematics was affected by employing a math lab during instruction. 100 JS 3 Mathematics students in total participated in the study. The study is a kind of simulated experiment. The data were analyzed using mean, standard deviation, and analysis of covariance (ANCOVA). The findings indicated that using a math lab enhanced students' mathematical achievement. According to the study, instructors should be encouraged to use mathematics laboratories to teach students about algebraic expression and plane geometry, and mathematics student teachers should receive training on how to use these laboratories in their methodology classes. Due to numerous impacts of laboratory-based learning strategy on the performance of students in geometrical concepts, with an increase in their analytical and problem-solving skills that has prompted this research to investigate its usefulness in the mathematics performance of students in junior secondary school in Obo-Akpor Local Government Area of Rivers State.

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Statement of the Problem

Many students regard mathematics as an abstract topic, which has contributed to their overall low performance in both internal and external exams. The reason for students' poor performance has been linked to a variety of factors, including a lack of instructional aids, students' nervousness and lack of interest, teachers' teaching strategies, a lack of teachers' exposure to real-life circumstances or a practical approach, and more. To curb this menace, different innovative teaching strategies (learners-centered) have been employed as against the traditional/ conventional way of teaching (teachers-centered) of which laboratory based learning strategy is one of the strategies used to arouse the interest of the students and to increase their level of performance in mathematics to meet the demanding need of the subject and to also help to build the; critical thinking, collaborative, creative, analytical and problem solving skills of the learners. Hence, this study aims at investigating the effectiveness of laboratory-based learning strategy over discussion-based instruction and the mathematics achievement of Junior Secondary School students in Geometry in Obio-Akpor Local Government Area of Rivers State.

Aim and Objectives of the Study

This study aimed to investigate the effect of laboratory-based instruction on the performance and retention of junior secondary students in plane geometry. In specific terms, the objectives of the study were to:

1. Determine whether there is any difference between the achievement of junior secondary school students who were taught plane geometry with laboratory-based instruction and those who were taught with discussion-based instruction.
2. Ascertain whether there is any difference between the retention of junior secondary school students who were taught plane geometry with laboratory-based instruction and those who were taught with discussion-based instruction.

Research Questions

The following four research questions were raised and answered.

1. What is the difference between the performance mean score of junior secondary school students who were taught plane geometry with laboratory-based instruction and those who were taught with discussion-based instruction?
2. What is the difference between the retention mean score of junior secondary school students who were taught plane geometry with laboratory-based instruction and those who were taught with discussion-based instruction?

Hypotheses

Two hypotheses were tested at a 0.05 significance level.

H_{O1}: There is no significant difference between the performance mean score of junior secondary school students who were taught plane geometry with laboratory-based instruction and those who were taught with discussion-based instruction

H_{O2}: There is no significant difference between the retention of junior secondary school students who were taught plane geometry with laboratory-based instruction and those who were taught with discussion-based instruction

Methodology

The study's research design was quasi-experimental. This research design included a pretest, a post-test, a non-randomised, and a non-equivalent control group. There were two groups, one of which was experimental and the other was control. In their respective intact classes, the children received treatment. The study was carried out in Obio-Akpor Local Government of Rivers State. A total of 119 junior secondary one students from Rivers State's Obio-Akpor local government area. The population of the study comprised all the 6,132 junior secondary school two (JS2) students in the sixteen 16 junior secondary schools in Obio-Akpor Local Government Area of Rivers State (Obio-Akpor Zonal Education Board, 2022). Two schools were chosen from the population using a deliberate sampling procedure. The schools that have a working mathematics laboratory or have a room that can be set up for mathematics laboratory activities were the ones that were chosen as the schools to attend. To designate one school as the experimental group and the other as the control group, simple random sampling was performed. The entire class that was used for the study in each school was chosen through a second random sampling. Fifty-nine (59) students formed the experimental whereas sixty (60) students formed the control group.

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Data for this study were gathered using a researcher achievement test. The test was known as the "Plane Geometry Achievement Test" (PGAT). This tool was employed to assess students' performance and recall in the area and perimeter of plane shapes. The instrument included A and B as components. In Part A of the exam, students were required to write their class and gender. To maintain their secrecy, the schools were designated on the script as E (Experimental School) and C (Control School). The ideas of perimeter and area of plane shapes that they were taught during the research investigation served as the basis for the PGAT items. There were 25 test items in the PGAT. The PGAT's items were multiple-choice questions with a stem and four lettered answer choices, from A to D. The students were told to select just one of the four viable answers. Each exam item included four possible answers, only one of which was the true solution; the other three were distractions. Students received 4 marks for each correct response to a test item on the PGAT instrument, while receiving a score of 0 for each erroneous response. The exam items were scored on a scale of 4 and multiples of 4 up to 100. The PGAT instrument received a total score of 100. The PGAT received a % grade.

The researcher gave a briefing on the study's goals and objectives to math teachers of complete classrooms on one particular day. Both the experimental and control groups' sample students initially completed the PGAT pretest. Following the administration of the pretest, the pretest scripts were assembled, scored in excess of one hundred, and then recorded. The math teachers of the intact classrooms then imparted the knowledge of plane geometry to the experimental and control groups. The experimental group's training was given to the control group, but with a discussion-based teaching strategy. The two groups received a posttest following the instructions. Additionally, the posttest scripts from the students, which were graded in %, were collected. A post-posttest of the PGAT was given to the sample students following a two-week grace period. The students' post-posttest scripts, which were graded in percentage, were also collected. For the posttest and post-posttest, the test items were switched around. Mean and standard deviation were used to provide descriptive answers to the study questions, and Analysis of Covariance (ANCOVA) was used to provide inferential answers by testing the null hypotheses at the 0.05 level of significance.

Results

Research Question 1: What is the difference between the performance mean score of junior secondary school students who were taught plane geometry with physical laboratory-based instruction and those who were taught with discussion-based instruction?

Table 1: Mean and standard deviation on the difference between the performance of students taught plane geometry using laboratory-based instruction and those taught with the discussion teaching method.

Group	N	Pretest Mean	SD	Posttest Mean	SD	Gain Mean	SD
LBI	59	28.35	11.51	51.30	14.15	22.95	13.58
DTM	60	29.77	10.32	40.51	13.82	10.74	7.35

Table 1 displays the mean and standard deviation of the performance disparity between students in the experimental group who were taught plane geometry using laboratory-based instruction and those in the control group who were taught using discussion-based instruction. Table 4.1's tabular presentation makes clear that students who learned plane geometry in a laboratory setting achieved mean gains of 22.95 and SDs of 13.58, whereas students in the control group who learned the subject through discussion-based instruction achieved mean gains of 10.74 and SDs of 7.35. This result shows that students with laboratory-based training in plane geometry did better than those with discussion-based training.

Research Question 2: What is the difference between the retention mean score of junior secondary school students who were taught plane geometry with laboratory-based instruction and those who were taught with discussion-based instruction?

Table 2: Mean and standard deviation on the difference between the retention of students taught plane geometry using laboratory-based instruction and those taught with the discussion teaching method.

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Group	N	Posttest Mean	SD	Post-Posttest Mean	SD	Gain Mean	SD
LBI	59	51.30	14.15	70.46	15.24	19.46	10.32
DTM	60	40.51	13.82	52.01	12.97	11.50	9.16

Table 2 compares the retention of students who learned plane geometry through laboratory-based instruction in the experimental group to students who learned the subject through discussion-based instruction in the control group. According to the tabular presentation in Table 4.2, students who learned plane geometry in a laboratory setting had a mean gain retention of 19.46, SD = 10.32, whereas students in the control group who learned the subject through discussion had a mean gain retention of 11.50, SD = 9.16. This research shows that students who acquired plane geometry in a laboratory setting retained the information better than those who learned it in a discussion-based setting.

Testing of Hypotheses

$H0_1$: There is no significant difference between the performance mean score of junior secondary school students who were taught plane geometry with laboratory-based instruction and those who were taught with discussion-based instruction.

Table 3: Summary of ANCOVA on the performance of students taught plane geometry with laboratory-based instruction and discussion teaching method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	549.607	2	273.803	61.911	.000
Intercept	1186.657	1	1186.657	268.322	.000
Pretest	424.397	1	424.397	95.963	.000
Group	7.050	1	7.050	1.594	.023
Error	428.000	116	4.423		
Total	44199.000	119			
Corrected Total	976.590	118			

R Squared = .522 (Adjusted R Squared = .741)

The results of the analysis of covariance (ANCOVA) were summarised in Table 3, showing the difference in performance between students who learnt plane geometry in a lab setting and those who did so through discussion-based instruction. According to Table 3, students who got discussion-based training and those who received laboratory-based teaching had significantly different performance mean scores (F1, 116=1.59, p =.02; p.05. HO1 was eliminated at a probability level of 0.05 because the p-value was less than 05.

$H0_2$: There is no significant difference between the retention of junior secondary school students who were taught plane geometry with laboratory-based instruction and those who were taught with discussion-based instruction.

Table 4: Summary of ANCOVA on retention of students taught plane geometry with laboratory-based instruction and discussion teaching method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3249.270	2	1624.636	11.539	.000
Intercept	1090.645	1	1090.645	7.746	.005
Posttest	2.577	1	2.577	.018	.030
Group	3239.168	1	3239.168	23.000	.000
Error	8025.311	116	140.795		
Total	227875.000	119			
Corrected Total	11274.583	118			

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R Squared = .881 (Adjusted R Squared = .754)

The results of an analysis of covariance (ANCOVA) on the difference in retention between students who acquired plane geometry in a lab setting and those who learned it through discussion-based instruction are summarised in Table 4. Student retention differs significantly between those who got discussion-based training and those who received laboratory-based instruction, as shown in Table 4 (F1, 116=23.00, p =.00; p.05. The second hypothesis was rejected at a probability level of 0.05.

Discussion

In the study described under this subheading, students in the experimental group who learned plane geometry through laboratory-based instruction saw a mean performance improvement of 22.95, SD=13.58, as opposed to those in the control group, who saw a mean performance gain of 10.74, SD=7.35. This demonstrated that students who studied plane geometry in a lab setting performed better than those who studied the subject in a classroom setting. This might be as a result of the fact that students were expected to do practical exercises in order to acquire the subject matter through the use of laboratory-based instruction. Students were encouraged to participate in class by using cardboard, cartons, and other tools, and they also entertainingly learned plane geometry. The performance mean score of students who got discussion-based instruction and those who received laboratory-based instruction differ significantly, according to statistical analysis (F1, 116= 1.58, p =.02; p.05). HO1 was eliminated at a probability level of 0.05 because the p-value was less than 05. These findings are consistent with those made by George and Edekor (2022), Onwioduokit (2014), Abel (2021), Salami (2022), Dharrriyat and Arivi (2020), and Okigbo and Osuafor (2008), who discovered that employing a mathematics lab enhanced students' performance in plane geometry.

The mean and standard deviation were used to compare retention between students who learned plane geometry through discussion and those who learned it through laboratory-based instruction. The findings showed that while students in the control group who got discussion-based instruction had a mean gain retention of 11.50, SD = 9.16, those in the experimental group who received laboratory-based instruction had a mean performance improvement of 19.46, SD = 10.32. The data analysis showed that students who learned plane geometry through laboratory-based instruction retained the information better than those who learned it through discussion-based instruction. The retention ability mean score of the students who received discussion-based instruction and those who received laboratory-based instruction were significantly different, it became obvious after statistical analysis of these results. F1, 116=23.00, p =.00; p .05. HO2 was disregarded at a probability level of 0.05 because the p-value was less than.05. This finding is in line with those of Ajai and Ogungbile (2023), and Ajai and Imoke (2015), whose research shows that students who receive mathematics instruction in a laboratory setting retain a significant amount of information regarding plane geometry.

Conclusion

Based on the findings of this study, it was concluded that laboratory-based instruction, which involves the engagement of students to construct their geometrical plane shapes and study their areas and perimeter, enhanced students' performance and retention; in other words, there was a statistically significant performance difference between the students who received discussion-based instruction and those who received laboratory-based training. With a statistically significant difference, students who were taught using a laboratory-based approach recalled more material than those who were taught using a discussion-based approach.

Recommendations

The following were recommended based on the findings of the study;

1. Laboratory-based instruction should be used to teach plane geometrical concepts because it is highly engaging and leaves it in the hands of the learners.
2. Continued practice and appropriate demonstration of the use of laboratory-based instruction should be carried out to help increase the learning effectiveness of these geometrical plane shapes.
3. Establishment of a physical laboratory in our public schools by the Ministry of Education and professional organisations. Also, for them to organise seminars and workshops to train mathematics teachers on the use of the mathematics laboratory to teach students plane geometry and to incorporate it into the teaching of other mathematics concepts for effective understanding of the concepts.

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Cite this article as:
Unamba, J. O. (2025). Comparative effects of laboratory-based and discussion-based instruction on junior secondary students' performance and retention in plane geometry. *FNAS Journal of Mathematics and Science Education, 7*(2), 45-53. https://doi.org/10.63561/fnas-jmse.v7i2.1089