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Effect of Activity-Based Learning Strategy on Understanding of Geometry Concepts among Senior Secondary School Student in Billiri, Gombe State, Nigeria

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Abstract
This study investigated the effect of Activity-based learning strategy and its effect on senior secondary two student's understanding in geometry, Billiri, Gombe State, Nigeria. The study was guided by two research questions and two hypotheses. The quasi-experimental research design involving a pre-test and post-test was used. A population comprising of 2,881 senior secondary two (SS2) students at public secondary schools in Billiri Metropolis. Six co-education schools were selected using the simple random sampling from which 274 students (Experimental = 127 and Control = 147) from intact classes were selected to participate in the study. One validated instrument with a reliability coefficient of 0.86 tagged: Geometry Understanding Test (GUT) was used for collecting data. The experimental group were taught geometry concept using the problem-solving strategy while the Control group were taught using the conventional method. The research questions were answered using descriptive statistics (mean and standard deviation) while the research hypotheses were tested using the analysis of covariance (ANCOVA) statistics at $p \leq 0.05$ level of significance. The result of the study revealed a significant difference in understanding in favour of students exposed to Activity-based learning. With regards to gender and understanding, there is significance difference in favour of the male gender. The study concludes that the activity-based learning is effective in the teaching and learning of geometry. In addition, activity-based learning was observed to be gender friendly. Based on these finding, it was recommended that teachers should employ the activity-based learning in the teaching of geometry at the senior secondary school level to enhance students' understanding in geometry. Also, workshops and seminars for mathematics and science-based teachers should be organized by the Gombe State Ministry of Education in Billiri, Gombe State on the use of the activity-based learning in classrooms.
Keywords: Understanding, Activity-Based Learning (ABL), Geometry, Secondary School Students

Introduction
Geometry remains one of the pivotal strands of mathematics education at the senior secondary school level in Nigeria, given its foundation role in developing spatial reasoning, logical thinking and real-life problem solving (Mark, 2016 as cited in Joseph, Ubebe & Aneshe-Otapha, 2022) however, research consistently reports that Nigerian students often struggle with geometry concepts, demonstrating low achievement and weak conceptual understanding (Josehp) et al, 2022. These challenges have attributed in part to traditional teacher-centered instructional method, large class sizes, limited set of manipulatives or active strategies, and low students' engagement (Dairo, Owonkwo, & Arekwe, 2023). In contrast, pedagogical approaches that engage students actively through tasks, manipulatives, peer interaction and hands-on experiences, commonly referred to as Activity-based learning (ABL) have shown internationally to improve understanding, motivation, and retention in Mathematics and in geometry (Adam & Enu, 2023). ABL emphasizes that learners explore, manipulative experiment and reflect, thereby aligning with constructivist and active learning theories which posit that knowledge is constructed rather than passively received (Priyono & Boedi, 2017), as cited in Joseph et al., 2022). In the Nigerian context, teachers' perceptions of ABL are becoming more favourable, yet its implementation is still challenged by resource constraints, class size and insufficient professional development (Dairo et al, 2023). While several instructional strategies have been investigated in geometry in Nigeria, such as laboratory-based method (Ajai & Ogugbile, 2021) and inquiry-based learning (Joseph & Ayodele, 2025), there remains a relative paucity of studies that apply Activity-based Learning specially with senior secondary two (SS2) students in geometry in Nigerian context. For instance, Durojaiye, Jekayinfa and Oloda (2023) examined the effect of Activity-Based Instructional Strategy on retention in circle geometry among SS2 students in Abuja and found significant benefits in favour of ABL group. However, their study focused on retention rather than broad understanding, and on a specific sub-topic (circle geometry). This suggests a gap in applying ABL broadly within geometry and measuring its effect on understanding of geometric concepts in SS2 classes. Activity-

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Based learning approach is a procedure where students are actively engaged in the lesson rather than just sitting, listening, and copying notes. This is an experimental learning class where students participate actively in the learning process. Rodwell (2017) has stated that positive learning experiences are more permanent. One of the basic features of activity-based learning is that one which appeals to different emotions and allows for different learning styles. The researcher also indicated that the process is entertaining for both the teacher and the learner, and that activity-based learning is more efficient than other methods when it comes to learning many things (Rodwell, 2017). Activity- based learning includes games, music, and nursery rhymes in the learning process. Such an activity can be entertaining for children; it is based on the 3Cs of curiosity, creativity, and collaboration.

The theory of understanding that was propounded by Richard Skemp in 1987 was used in this study. According to Skemp, learners construct schemata to link what they already know with new learning. Skemp observed that mathematics involves an extensive hierarchy of concepts – we cannot form any particular concept until we have formed all the subsidiary ones upon which it depends. He suggested that emotions play a dominant part in the way in which we learn. The theory provides two kinds of learning in mathematics:

1. Instrumental understanding: A mechanical, rote or 'learn the rule/method/algorithm' kind of learning (knowing how to do something), and
2. Relational understanding: A more meaningful learning in which the learner can understand the links and relationships (knowing why something works) which give mathematics its structure (which is more beneficial in the long term and aids motivation).

Geometry is that aspect of mathematics that enables man to make prediction about the world. Geometry came into being independently in a few early cultures of humanity as practical ways for dealing with lengths, areas and volume of objects and this has influences on many fields such as architecture, physics and other branches of mathematics (Zuya & Kwalat, 2015). According to Kurumeh, Obarakpo, Odoh and kyereve (2016) geometry is seen as a basic and important branch of Mathematics that deals with the study of size, shape and position of 2- dimensional shapes and 3-dimensional figures. Geometry is a branch of Mathematics that deals with points, lines sizes, angles, surfaces, solids and shapes. Geometry is included in most of the school curricula over the world considering its considerable benefits and application in life (Arici & Aslan-Tutak, 2013). They further noted that geometry instruction develops students' spatial and perceptual abilities to interpret the dimensionality of the physical world. Geometry appears naturally in the structure of the solar system, a geological formation, rocks and crystals, plants, and flowers, and even in animals. It is also a major part of the synthetic world such as art, architecture, cars, machines and virtually everything humans create (Fabiyi, 2017). Gender is included as a moderating variable because previous Nigerian studies have examined whether male and female students respond differently to problem-solving instruction in geometry (Obinatu & Omebe, 2025; Shu'iabu & Sidi, 2020).

Susilawati, Suryadi, and Dahlan (2017) explained that geometry teaching is expected to provide an attitude or to visualize the relationship and characteristics of geometrical spaces. They emphasize that students should be provided with the opportunity and sufficient supporting learning media so that they can observe, explore, and find out geometrical principles through informal activities before applying what they have informally learned in their formal learning activities. Andriani (2020) in a study titled understanding the concept of geometry through the connected Mathematics project learning by using online media and local culture, acknowledge that Mathematics learning is very important, but it is found to be very difficult for the students. The connected mathematics project-based learning (CMP) is mathematics learning that raised everyday problems in life to explore mathematical ideas so as to foster the student-centred learning environment to solve their problems by an investigation. Samosir, Dahlan, Herman, and Prabawanto (2023), in their study titled "exploring students' mathematical understanding according to Skemp's Theory in Solving Statistical Problems" aimed at exploring students' conceptual understanding. The research was qualitative research with phenomenology. The results of this study are as follows. (1) students with relational understanding are fewer in number than students with instrumental understanding. (2) students find it most difficult to use the interconnections of various mathematical concepts in solving problems. (3) students' difficulties are due to their lack of ability in the concept of basic operations and their lack of

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understanding of the problems. Nurjanah, Jarnawi, and Wibisono (2021), in their study titled the effect of hands-on and computer based learning activities on conceptual understending and mathematics reasoning, compared two treatments namely the use of hands on activity media and computer-based media on the conceptual understanding of mathematics and the reasoning ability of students. The results showed that; the ability to understand mathematical concepts from groups of students who use computer-based media differs significantly from groups of students who use hands-on activity media and control groups.

Statement of the Problem

The persistent poor performance of senior secondary school students in standardized examinations such as the West African Senior School Certificate Examination (WASSCE) in Nigeria has been of great concern to stakeholders like parents, government, teachers and professional groups. They have lamented the poor performance of secondary school students particularly in Mathematics for which geometry is the aspect students find difficult leading to poor performance. In response to this condition in the education sector, attempts are made towards addressing this challenge. Geometry is one aspect of mathematics that creates phobia and anxiety among students which is evident in their outcome. Most research studies showed that geometry is one of the areas that most of the students find very difficult to handle during examinations. They cannot solve simple calculations such as determining the volume of spheres, surface area and perimeter of shapes. Therefore, this study examined how Activity-Based learning approach (problem solving) can improve students` understanding in geometry and mathematics generally.

Purpose of the Study

The main purpose of the study was to investigate the effect of activity-based learning strategy on students' understanding in geometry. Specifically, the study's objectives are to:

1. investigate the effect of activity-based learning (problem solving) strategy on students' understanding in geometry.
2. ascertain the understanding of male and female students in geometry when exposed to the ABL.

Research Questions

The following questions were raised to help as a guide to the study:

1. What is the difference in mean scores on understanding of students taught geometry using ABL and those taught using the conventional method?
2. What is the difference in the mean understanding scres of male and female students taught geometry using the ABL?

Research Hypotheses

The following hypotheses were tested at 0.05 level of significant.

1. There is no significant difference in mean understanding scores of students taught geometry using ABL and those taught using the conventional teaching method.
2. There is no significant difference in the mean understanding scores of male and female students taught geometry using ABL

Research Methodology

The research design adopted for this study was the quasi-experimental research design, which comprised of two-groups, one experimental (EG) and the other control (CG). Both groups were pretested before the administration of treatment to ensure uniformity and equivalence in performance at entry point. The treatment (X_1 - Activity-Based Learning) was administered to students in the experimental group only; while students in the control group were taught using the Conventional method which implies no treatment (X_O). A Post-test was administered after treatment to both groups of students to determine their respective performance. The target population is 4103 students (2527 males & 1576 females) from the co-educational public schools in Billiri for the 2024/2025 academic session. Six schools were selected using the simple random sampling as the sample school for the study. Six (6) intact classes from the SS2 arms were selected by simple random method from the schools. The sample for the study which comprised 274 students, 127 for the experimental group and 147 students for the control group. The researcher made instrument was used for data collection in this study which was titled Geometry Understanding Test (GUT): This is a 30-item objective test on geometry for the students to answer all. This set of questions are in line with the geometry topics for SS2. Each question has a total score of 1 mark

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therefore making the test out of 30 marks. The face and content validity of GPT was established by two experts in mathematics education and one expert in measurement and evaluation. Reliability of the instrument was estimated to be 0.86 by using kuder-Richardson (K-20) reliability method. Before treatment both experimental and control groups were pre-tested. Thereafter, the experimental group was taught geometry using the ABL. The students were given opportunity to interact with one another during the process of learning the concept while the teacher guided them in different situations. The control group was taught the same topics with the lesson plan using the conventional method. Data collected were analysed using descriptive statistics of mean and standard deviation, to answer the research questions. The hypotheses were tested using the analysis of covariance (ANCOVA) at 0.05 level of significance.

Presentation of Results

This section presents the result of data collected from the study, findings and the discussion of findings. The results for the study are presented in tables followed by report explaining the tables.

Research Question One

What is the difference in the mean scores of students' understanding between those taught geometry using Activity-based learning approach and those taught using the direct instruction method?

Table 1: Descriptive statistics for understanding between the experimental and control groups.

Strategies		Pre understanding	Post understanding	Mean gain
Activity-Based Learning Problem Solving Approach	Mean	9.82	17.18	7.36
	N	127	127	
	Std. Deviation	2.80	3.19	
Direct Instruction Method	Mean	8.86	12.32	3.46
	N	147	147	
	Std. Deviation	2.82	2.23	
Mean difference		0.96	4.86	3.90

Table 1 shows that the experimental group had a mean gain of 7.36 while the control group had a mean gain of 3.46. In addition, the mean difference was computed to be 3.90. This difference is in favour of the students exposed to the ABL who performed better than their counterparts who were taught using the conventional method.

Research Question Two

What is the effect of Activity-based learning problem solving approach on students' understanding of geometry in senior secondary schools across gender?

Table 2: Descriptive Statistics on Performance Between Male and Female in the Experimental Group

Gender		Pre understanding	Post understanding	Mean gain
Male	Mean	10.42	18.30	7.88
	N	77	77	
	Std. Deviation	2.81	2.95	
Female	Mean	8.90	15.46	6.56
	N	50	50	
	Std. Deviation	2.56	2.78	
Mean difference		1.52	2.84	1.32

From Table 2, the mean gain for male students was 7.88 while that of female students was 6.56. The mean difference in gain between the groups was 1.32. Clearly, a difference exists between the male and female students in favour of the latter. Hence the male students performed better than the females.

Hypothesis One

There is no significant difference between the mean understanding scores of students taught geometry using activity-based learning, problem solving approach and those taught using the direct instruction method.

Table 3: ANCOVA Test for Performance between Experimental and Control Groups

Dependent Variable: PostGUT

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2421.787[a]	2	1210.893	273.664	.000	.669

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Intercept	1843.125	1	1843.125	416.550	.000	.606
PreGUT	816.057	1	816.057	184.431	.000	.405
Strategies	1206.218	1	1206.218	272.608	.000	.501
Error	1199.104	271	4.425			
Total	61840.000	274				
Corrected Total	3620.891	273				

a. R Squared = .669 (Adjusted R Squared = .666)

Table 3 shows the summary of ANCOVA test results for experimental and control groups. The result shows that F(1,271) =272.608 ,P =.000<.005). Since the p value of .001 is less than the set significant value of the study (p< .005), the null hypothesis one was rejected. This indicates that, there is significant difference in the mean performance scores of SS2 students taught geometry using ABL and those taught using the conventional method.

Hypothesis Two

There is no significant difference between the mean understanding levels of male and female students taught using the activity-based learning problem solving approach.

Table 4 ANCOVA Test for understanding between Male and Female Students in the Experimental Group

Dependent Variable: PostGUT

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	681.127[a]	2	340.564	69.720	.000	.529
Intercept	962.047	1	962.047	196.950	.000	.614
PreGUT	436.843	1	436.843	89.430	.000	.419
Gender	91.070	1	91.070	18.644	.000	.131
Error	605.707	124	4.885			
Total	38776.000	127				
Corrected Total	1286.835	126				

a. R Squared = .529 (Adjusted R Squared = .522)

The result in Table 4 shows that F(1,124) = .18.644, revealed a p-value of 0.514 > 0.05 was obtained. Thus, the null hypothesis 2 was rejected. This means that there is statistically significant difference between the mean score of male and female students taught geometry using ABL.

Discussion of Findings

The findings from the study shows that the experimental group exposed to the ABL problem-solving strategy understood better than the control group taught using the conventional method evidenced by the formers higher mean score. In addition, it was revealed that a significant difference between the understanding of students in problem-solving strategy and those in the Conventional group existed. This findings agrees with Samosir, Dahlan, Herman, and Prabawanto (2023), Durojaiye, Jekayinfa and Oloda (2023), Nurjanah, Jarnawi, and Wibisono (2021), Mokiwa and Agbenyeku (2019), who reported that students who were taught using the problem-solving strategy had a better understanding of geometry than others taught by the conventional method. The reason for this was that students in the problem-solving strategy group carried out many activities in the classroom which required them also to collaborates with their colleagues. In addition, their interest was aroused since they were able to relate abstract to real life examples. The finding agrees with Andriani (2020) that the average score of students' ability in understanding the concept of geometry among students who were given material based on local culture was higher than students who were given material that was not based on local culture. The finding agrees with Adam and Enu, 2023, that the problem-solving approach when applied to classroom instruction can significantly improve understanding in mathematics. The finding agrees with (Rodwell, 2017), that students taught mathematics through Activity based method differ significantly in Motivation as compared to the control group (Traditional Teaching method). The use of activity-based learning, problem solving approach enabled students to turn abstract information into experience and internalise earlier learning. The utilization of activity-based learning, problem solving approach helps students analyse and learn by practicing using practical experience in Mathematics class.

Conclusion

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The study established that the use of problem-solving strategy to teach geometry in senior secondary school helps to increase students' confidence in solving geometric problems.

Recommendations

1. Considering the results of this study, teachers should be encouraged to use activity-based learning approach in their classes always.
2. Teachers should be trained and retrained on how to use the different activity-based approaches to teach different topics in Mathematics.
3. Teachers should always encourage students to participate in any new strategy of learning that makes think to solve their problems.
4. Based on the findings of this study, government and policy makers should integrate activity-based learning into the national policy.

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