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Effects of Problem-Based Learning Strategy on Students' Ability and Interest in Solving Solid Geometry in Senior Secondary School in Sokoto State, Nigeria

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Abstract

This study investigated the effect of Problem-Based Learning Strategy on Students' Ability and Interest in Solving Solid Geometry in Senior Secondary Schools in Sokoto State, Nigeria. The study employed a quasi-experimental pre-test and post-test design; the experimental group was taught using problem-based learning strategy while the control group was taught using the conventional (Discussion and Demonstration) method. The population of the study consisted of all public senior Secondary School Students in Sokoto State, estimated to be 31,998 students. A sample of 94 SSI students was selected using a purposive sampling technique. Two Senior Secondary Schools were used for the study, and in each of the two schools, one intact class was used as either the experimental or control group. Two instruments were used for data collection, namely the Solid Geometry Ability Test (SGAT) and the Solid Geometry Interest Questionnaire (SGIQ). Two research questions were answered using mean and standard deviation, while the hypothesis was tested at 0.05 level of significance using an independent sample t-test. The Results showed that the problem-based learning strategy had higher ability scores in solid geometry and fostered greater interest compared to the conventional method among senior Secondary School Students in Sokoto State, Nigeria. The study recommended that Mathematics teachers should adopt a problem-based learning strategy in teaching solid Geometry so that teaching and learning of the concept will be student-centered. The Government, in collaboration with curriculum planners, should integrate problem-based learning as a teaching strategy in senior secondary schools in Sokoto State. Training and retraining of mathematics teachers on the effective use of PBL in their Schools

Keywords: Problem Based Learning, Students' Interest, Students' Ability, and Solid Geometry

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Introduction

Mathematics is a subject that is universally recognized as one of the major requirements for scientific, technological, and engineering advancement. In Nigeria, mathematics is a compulsory subject in the Senior Secondary School curriculum and relevant in all fields of study, particularly in the fields of science, medicine, engineering, and technology (Onoshakpokaiye & Avwiri, 2025). Despite its importance, students' performance in mathematics has remained persistently poor, as highlighted in annual reports released by the West African Examination Council (WAEC; 2023, 2024 & 2025). One of the areas where students experience difficulty is Solid Geometry which is the essential components of Geometry in the mathematics curriculum that involves the study of three-dimensional (3D) solid shapes and their real-life application (Bilolkhan, 2024).

Geometry is one of the branches of mathematics that deals with the nature and relationship of lines, angles, curves, and shapes, etc. (Ozochinanuife *et al.,* 2023). Geometry is included in the school curriculum around the world due to its benefits and applications in real life (Effiom & Abdullahi, 2021). Learning geometry is not an easy task as most of the students fail to develop an understanding of geometric concepts, geometric reasoning, and skills in solving geometric problems (Shu'iabu & Sidi, 2020). Thus, students need to develop skills in solving geometric problems (Hassan et al., 2023). As such, Geometry holds significant position in the mathematics curriculum. Students acquire a wide range of knowledge and skills in many applications of geometry. They possess knowledge of geometric construction and engage in learning geometric shapes. Geometry facilitates the exploration and understanding of the features and attributes of various shapes.

Solid Geometry is a branch of geometry that deals with three-dimensional (3D) solid shapes (Bilolkhan, 2024). A Solid geometric is a figure or shape that has a three-dimensional structure. In simple words, they have volume, length, width, and height. However, solid geometry is divided into two major types, namely: Polyhedron and non-polyhedron or Curved Bodies (Asiamah& Fletcher, 2023). Polyhedron comprises solids that have multiple faces, all of which are flat. Each face is a polygon. Examples include cubes, prisms, pyramids, etc. While non -polyhedrons include solids with curved surfaces or a combination of curved and flat surfaces. Examples include sphere, cone,

cylinder, etc. The common examples of solid geometric figures are a cone, sphere, cube, and cuboids. The geometric solid cube has three dimensions: length, width, and height (Seabra *et al.,* 2021).

Student's Ability in solving solid geometry refers to the capacity of the students to understand, analyze, and apply principles in solving three-dimensional figures such as cubes, cuboids, cones, pyramids, spheres, and their properties which includes volume and surface area (Kusuma *et al.,* 2023). Developing Ability in this area required the following aspects. Spatial visualization, Analytical reasoning, problem-solving skills, geometric construction, abstract thinking, and measurement Skills (Herrera *et al.,* 2019).

Students' interest refers to the state of engaging students in learning solid geometry (Wong & Wong, 2019). This study considers students' interest as the state of being confident and free in interacting with teachers and colleagues in the learning process. More so, Emefa *et al.* (2020) viewed that interest as an interaction between a person and a specific subject or activity, including the process of willingness, attention, concentration, and positive feeling. In their study, Toli and Kallery (2021) provided the characteristics of interest that include increased attention, efforts, effects, and experience. The trend of poor ability in solving solid geometry problems is associated with students' low interest in learning mathematics in general and solid geometry in particular. Therefore, there is a need for an innovative strategy like problem-based learning PBL which emphasizes on students' collaboration, active engagement in solving real-life problems.

Problem-Based Learning (PBL) is a student-cantered instructional strategy where the teacher introduces students to a particular problem and offers students more opportunities to discover important concepts by themselves under the guidance of the teacher, who serves as a facilitator. PBL is a student-cantered approach in which students learn about a subject by attempting to find a solution to a problem (Ogunsola et al., 2021). Problem-Based Learning is one of the teaching models that require students to be active, collaborative, and student-cantered, develop their problem-solving skills, and engage in independent learningin which the students work in groups to formulate problems that have been given (Folashade, 2023). Likewise, Gallagher (2015) stated that PBL could be trusted to help the development of creative thinking skills among students in various fields of education. The teacher guides students and facilitates learning, organizes learning assignments, mediates

problem formulation, and formulates hypotheses. Students work in groups to solve problems that have been given previously. One of the problems that can be used is an open-ended problem, which is a problem that has a variety of solutions or strategies (Tan, 2021).

Theoretical Foundations

The theoretical foundation of this study is based on two theories, which are considered relevant to the study, they are: Experiential learning theory (ELT) by David Kolb 1984 and social constructivist theory (SCT) by Lev Vygostsky 1968). The two theories were considered relevant to the study because both of the theories exhibit similar characteristics to problem-based learning. According to Kolb 1984, learning occurs through experience and comes up with four staged learning cycle which are Concrete experience, Reflective Experience, Abstract Conceptualization and Active Experimentation in these four stage cycle learners were exposed to real life solid geometry problem (Concrete Experience) in which they reflect and discuss the possible solution (Reflective Observation) and then develop geometric concepts (Abstract Conceptualization) and apply these concepts to real life problems (Active Experimentation). This shows that Experiential learning theory aligns with problem-based learning because students learn by doing, which enhances their ability in solving solid geometry. Likewise the Social Constructivist theory by Lev. Vygotsky 1968 emphasized that learning occurs through social interaction, Collaboration and teachers guidance (Facilitation) which aligns with PBL in improving students' interest through interaction and Collaboration. Figure 1 presents the pictorial representation of the theories that guide the study.

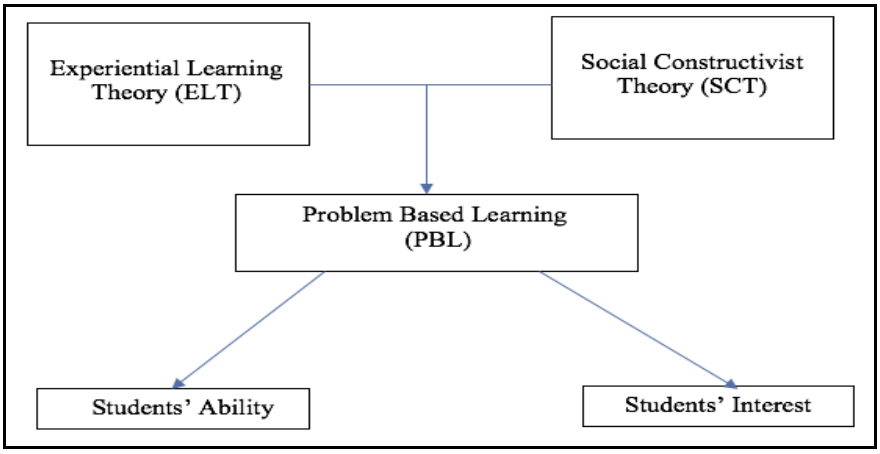

Figure 1: Theoretical Framework

Statement of the Problem

Solid geometry is a fundamental component of mathematics that is taught at the senior secondary school level. Ideally, the teaching and learning of solid geometry is expected to make students creative and develop the ability to solve real-life problems, and also develop positive interest in solving solid geometry concepts. Despite its importance, presently, students in senior secondary schools in Sokoto state are showing a lack of interest and ability in solving solid geometric problems. These trends can be attributed to several learners psychological factors like poor self-concept, poor self-esteem, teachers attitudes and above all in-adequate knowledge by the teachers of an innovative strategies like problem based learning PBL, which results to lack of interest and ability in solid geometry, furthermore, in many senior secondary schools in Sokoto state, teachers relies heavily on traditional method which is a teacher cantered with less emphasis on real-life application and students engagement.

Consequently, students' interest and ability in solid geometry remain poor as many students are faced with difficulties in visualizing three-dimensional objects, solving geometry problems, and applying their knowledge in practical forms. Therefore, there is a need to adopt an innovative strategy like problem-based learning PBL which emphasizes on students collaboration, active engagement in solving real-life problems. Several researches have been conducted, on improve students' ability and interest in solid geometry to enable them applies the knowledge in solving real-life practical problems. Often all the literature reviewed; there is no research study of such nature that is conducted in Sokoto state. These necessitated the researcher to conduct research to examine the effects of students' ability and interest in solving solid geometry using a problem-based learning strategy among senior secondary schools in Sokoto state, Nigeria.

Objectives of the Study

The main objective of the study is to determine the effects of a problem-based learning strategy on students' Ability and interest in solving Solid Geometry among senior secondary schools in Sokoto State, Nigeria, and the specific objectives are to:

I. Determine the difference in the ability of students taught using a problem-based learning strategy and those taught using a conventional method in solving solid geometry among senior secondary schools in Sokoto State, Nigeria.

II. Determine students' interest in solving solid geometry using a problem-based learning strategy among senior secondary schools in Sokoto State, Nigeria.

Research Questions

In line with the objectives of the study, the following research questions were raised in this study:

I. What is the difference in the ability of students taught using a problem-based learning strategy and those taught using a conventional method in solving solid geometry among senior secondary schools in Sokoto state, Nigeria?

II. What is the student's interest in solving solid geometry using a problem-based learning strategy among senior secondary schools in Sokoto State, Nigeria?

Null Hypotheses

On the basis of research questions, one null hypothesis was tested at 0.05 level of significance.

HO_1. There is no significant difference in the ability of students taught using a problem-based learning strategy and those taught using a conventional method in solving solid geometry among senior secondary schools in Sokoto State, Nigeria

Methodology

The study employed quasi experimental research design with a pre-test–post-test to investigate the effects of a problem-based learning strategy on students' ability and interest in solving solid Geometry. A sample of 94 SSI Students were purposefully selected from two senior secondary schools from the population of 31,998 SSI Students in Sokoto state, out of which 46 students were assigned to the experimental group who received instructions on

problem-based learning, and 48 were assigned to the control group that was taught using a conventional method. Two instruments were used for data collection, namely: Solid Geometry Ability Test (SGAT)and Solid Geometry Interest Questionnaire (SGIQ), which were validated by three experts. Reliability coefficients of 0.83 and 0.88 were obtained using Cronbach's alpha and the Pearson Product-Moment Correlation coefficient (PPMC), respectively. The data collected were analyzed using mean and standard deviation**.** Students in both groups received instruction for six weeks**,** after which a post-test was administered to determine the effect of PBL on students' Ability and Interest in solving Solid Geometry. The research design is illustrated in Figure 1 below.

Figure 1: Pre-Test and Post-Test Quasi-Experimental Design

Key: $P_1 = Pre-test, P_2 = Post-test and X =$ Intervention

Results

Based on the result obtained, the analysis and interpretation were done with the use of a table to provide a clear picture of the findings as follows:

Research Question One

What is the difference in the mean ability in solving solid geometry between students taught using a problem-based learning strategy and those taught using a conventional method among senior secondary schools in Sokoto State, Nigeria?

To answer this research question, scores obtained from 94 were used and analyzed using mean and standard deviation, as presented in Table 1below.

Table 1: Summary of Mean and Standard Deviation of Students' Ability in Solving Solid Geometry between Experimental and Control groups.

Group	N	Mean	Std. Deviation	Mean Difference
Experimental Group	46	21.13	4.52	
				8.92
Control Group	48	12.21	6.78	

Total	94

Table 1 shows the mean scores of 21.13 and a standard deviation of 4.52 for the Experimental Group and the mean scores of 12.21 and a standard deviation of 6.78 for the control group. The mean difference between the groups is 8.92. The results indicated that the experimental group had a higher mean score than the control group, which signifies that problem-based learning was effective in enhancing students' ability to solve problems in solid geometry among senior secondary schools in Sokoto State, Nigeria.

Research Question Two

What is the students' interest in solving solid geometry among senior secondary schools in Sokoto State, Nigeria?

To answer this question, responses obtained from the 94 students who were administered the Solid Geometry Interest Questionnaire were sorted and analyzed using mean and standard deviation, as presented in Table 2 below

Table 2: Summary of Students' interest in solving solid geometry

S/N	Item	N	Mean	STD
1	I feel confident when solving solid geometric problems	94	2.69	1.047
2	I am more interested in spending my time in solid geometry than in any other topic in mathematics	94	2.75	1.019
3	I find solving solid geometry interesting in class	94	2.69	1.013
4	I enjoy visualizing three-dimensional objects in solid geometry	94	2.67	1.037
5	My interest in solving solid geometry problems improves my solving ability in mathematics	94	2.67	1.015
6	Solving a solid geometry problem is boring and time-consuming	94	2.74	.967
7	The real-life application of solid geometry makes it interesting	94	2.65	1.012
8	I received adequate attention from my teacher when solving solid geometry Problems	94	2.76	1.053
9	I will work as long as necessary to solve solid geometry problems	94	2.64	1.000
10	Solving Solid Geometry problems is not of my interest	94	2.67	1.023
Total		94	29.59	6.901

Source: field work, 2025

The overall mean interest score is 29.59 with a standard deviation of 6.901, suggesting overall moderate interest levels in solid geometry among students. Interest appears moderate across various aspects like visualization, applications, and confidence. Contextual factors like teaching approaches and perceived relevance might influence these interest levels.

Research Hypotheses Testing

The null hypothesis was tested at 0.05 level of Significance using an Independent Sample t-test for the Experimental and Control groups.

Analysis of the Research Hypothesis One

$H_0$1: There is no significant difference in the ability of students taught using a problem-based learning strategy and those taught using a conventional method in solving solid geometry among senior secondary schools in Sokoto state, Nigeria. This null hypothesis is tested using an independent sample t-test for the experimental and control groups, as presented in Table 3.

Table 3: Independent Sample t-test on the Ability of Students in the Experimental and Control Groups

Test	N	Mean	Std. Deviation	Df	T	P-value	Decision
EG	46	21.13	4.52				
				92	3.59	.001	Null H_0 Rejected
CG	48	12.21	6.78				
Total	94						

Source: Field work (2025) Level of significance=0.05

Table 3 Shows the independent sample t-test comparing the mean score of the experimental and control groups. The experimental group had a high mean score (Mean=21.13; SD=4.52) compared to the control group (Mean= 12.21; SD= 6.78). The t-value of 3.59 with a p-value = .001, which is less than the 0.05 level of significance. Since $p < 0.05$, this signifies that a statistically significant difference exists in the ability of students taught using a problem-based learning strategy compared to conventional methods in solving solid geometry. This indicates that the hypothesis is rejected; indicating that solving solid geometry using problem-based learning has a greater effect on students' ability than the conventional method.

Summary of the major Findings

The following are the summary of the major findings of the study.

I. Students taught with problem-based learning had higher ability scores than those taught using the conventional method among senior secondary schools in Sokoto State, Nigeria.

II. There is a moderate level of students' interest in solid geometry using a problem-based learning strategy among senior secondary schools in Sokoto State, Nigeria.

Discussion

Findings revealed that students taught with problem-based learning showed higher ability scores than those taught using the conventional method, indicating Problem-Based Learning be a more effective approach for solid geometry. This aligns with research suggesting PBL enhances performance in mathematics and geometry. Ramli *et al.* (2020) found that PBL led to higher mathematical values among Malaysian students. Eneze *et al.* (2020) reported that PBL outperformed expository methods in geometry achievement in Nigerian schools. The outcome hints at PBL's potential superiority in teaching solid geometry in Sokoto State, Nigeria. PBL's emphasis on active problem-solving likely contributes to improved learning outcomes. The approach appears beneficial for developing solid geometry skills among senior secondary students. Findings support considering PBL as a viable strategy for teaching geometry, reflecting broader trends in educational research valuing active, problem-centric learning. Implementation aspects like teacher facilitation and adapting PBL to local contexts probably influence its effectiveness. Studies show PBL's benefits across settings, sometimes shaped by factors like prior math knowledge (Jamaan *et al.,* 2018). Overall, results suggest PBL could be an effective way to enhance solid geometry abilities, fitting with notions of PBL fostering deeper learning in mathematics.

The outcome also revealed that Problem-Based Learning had an impact on students' solid geometry abilities, likely reflecting improvement given the pre-post comparison context. The finding aligns with perspectives on PBL fostering skill development through active engagement. It indicates students' solid geometry solving abilities differed after experiencing PBL, consistent with studies highlighting PBL's positive geometry learning outcomes (Jamaan *et al.* 2018). PBL's problem-centric approach probably contributed to these ability changes. Implications include support for using PBL to enhance geometry problem-solving competencies. The significant difference hints at PBL's potential for improving solid geometry abilities, encouraging consideration of PBL strategies for mathematics teaching. Contextual factors like implementation quality, teacher support, and local educational conditions might shape PBL's impact. The direction of change likely indicates

improvement, fitting notions of PBL promoting active learning, beneficial for mathematics outcomes.

The findings of this study also reveal that PBL fostered greater interest in solid geometry. Interest increase supports PBL's potential for improving emotional engagement with the subject. Findings like Jimoh and Fatokun (2020) showed PBL improved interest in chemistry topics, resonating with this enhancement. PBL's interactive nature probably contributed to heightened interest. Implications include that increased interest could promote more effective learning of solid geometry.

Recommendations

Based on the findings of the study, the following recommendations were made:

I. Mathematics teachers should adopt a problem-based learning strategy in teaching solid Geometry so that teaching and learning of solid geometry will be student-centered.

II. The Government, in collaboration with curriculum planners, should integrate problem-based learning as a teaching strategy in senior secondary schools in Sokoto State. And also organize training and retraining of mathematics teachers on the effective use of PBL in teaching their students.

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