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Effect of Problem-Based Learning Strategy on Senior Secondary School One Students' Achievement and Retention in Mathematics in Apa Local Government Area, Benue State, Nigeria

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Abstract: *The focus of this study was to examine the effect of Problem-Based Learning (PBL) on Senior Secondary School One students' achievement and retention in Mathematics in Apa Local Government Area of Benue State, Nigeria, using a pre-test, post-test, non-equivalent control group quasi-experimental design. Two research questions guided the study, and two hypotheses were formulated and tested at a 0.05 level of significance. A sample of 150 students was selected using a multi-stage sampling technique, with intact classes from Senior Secondary School One participating. The experimental group was taught using the PBL approach, while the control group received instruction through the Traditional Method (TM). Data were collected using a Mathematics Achievement Test (MAT) with a reliability index of 0.78 and a Mathematics Retention Test (MRT), which was similar in content but different in structure from the MAT. Mean and standard deviation were employed to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at the 0.05 significance level. Findings revealed that PBL had a significant effect on students' achievement and retention in Mathematics. The study concluded that the use of PBL would greatly benefit education stakeholders by improving the quality of Mathematics teaching and learning, as well as enhancing students' ability to apply knowledge to real-world problem solving. It was therefore recommended that Mathematics teachers integrate PBL strategies into classroom instruction to foster improved achievement and retention, and that training workshops be organized to equip teachers with the necessary skills for effective PBL implementation.*

Keywords: achievement, learning strategy, problem-based learning, retention,

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INTRODUCTION

Education today emphasizes the production of students who possess 21st-century skills and holistic personalities to meet emerging global challenges and remain competitive. Consequently, the focus of education has shifted from teacher-centered to student-centered approaches, encouraging active learning, creativity, critical thinking, and problem-solving, particularly through thinking, communication, and collaboration. Mathematics education, in particular, emphasizes the development of students' cognitive skills such as problem-solving, reasoning, creative and innovative thinking (Laine & Muhammad, 2022). Problem-Based Learning (PBL) is one of the teaching strategies believed to enhance students' 21st-century learning skills, especially higher-order thinking skills (HOTS). Research shows that PBL improves students' critical thinking abilities (Aliyu, 2019) and increases motivation in problem-solving (Suwono & Dewi, 2019).

The PBL method was first implemented in K-12 schools in the United States for various subjects in 1993 by Barrows and Kelson (Torp & Sage, 1998). Since then, it has evolved into an innovative and globally recognized instructional approach (Silva et al., 2018). The method typically involves five stages: understanding the problem, collaborative discussion, solution generation, reflection, and presentation of results (Silver et al., 2016). In practice, students are expected to analyze and understand problems, collaborate with peers, search for relevant information from diverse sources, and apply this knowledge to generate solutions. By engaging students in solving real-life problems through group discussions and teamwork, PBL fosters problem-solving competence and collaboration skills (Mokter, 2019).

However, reports from the West African Examinations Council (WAEC) Chief Examiner on Mathematics performance between 2019 and 2022 indicate persistent weaknesses among students. These include poor interpretation of questions, inability to draw diagrams to aid problem-solving, weaknesses in number manipulation, poor handling of currency values, difficulties in graph drawing, resolution of forces, and construction. Such deficiencies have been linked to the dominance of traditional teaching methods (TM) in Mathematics classrooms, which contribute significantly to students' poor performance (Van & Maree, 2007).

PBL, by contrast, positions the teacher as a facilitator and the students as active learners. Torp and Linda (2020) emphasized that in a PBL classroom, teachers act as coaches while students drive the learning process. Similarly, Greenwald (2020) described PBL as a constructivist process where learning is shaped and directed primarily by students, with instructors serving as "thinking coaches." This learner-centered approach empowers students to decide what they need to know and how to approach problem-solving, making them independent learners and problem solvers. PBL incorporates diverse techniques such as questioning, role-playing, brainstorming, projects, field trips, interviews, and library research (Adewuya, 2012). These activities engage students in critical thinking, knowledge seeking, analyzing, hypothesis formulation, experimentation, and collaborative inquiry. Researchers, including Kurumeh (2016) and Etukudo & Utin (2015), have

stressed the need to move away from the traditional approach toward more interactive strategies like PBL to enhance Mathematics achievement.

To sustain students' interest, attention, confidence, and achievement, pedagogical practices and instructional methods must emphasize mathematics-based expertise. Teachers should equip students with domain-specific knowledge, guide them in organizing this knowledge meaningfully, and provide opportunities to apply it in problem-solving. Within this cognitive framework, PBL has been shown to significantly enhance students' achievement in Mathematics. Academic achievement is generally viewed as the knowledge, skills, and ideas students acquire and retain during their studies (Ezeudu, 2013). A high level of performance in academic tasks indicates high achievement, while poor results indicate low achievement. It is often measured through examinations or continuous assessments, though there is no universal agreement on the best method of measurement (Okeke, 2016). Academic achievement encompasses not only test scores but also the ability to access, apply, and integrate knowledge, as influenced by motivation and learning styles (Kalana, 2015; Williams, 2018).

Perspectives on achievement vary: some consider it a motivational concept involving the drive to succeed, while others view it behaviorally, as actions directed toward meeting standards of excellence (Shaffer, 2012; 2015). Academic performance, on the other hand, reflects demonstrated learning outcomes, such as knowledge retention, recall, and application (Kalu, 2018). Thus, academic achievement represents a measurable change in behavior resulting from learning experiences (Eneshin, 2013). Several studies confirm the positive effect of PBL on Mathematics achievement. For instance, Ramli et al. (2020) found significant improvements in both achievement and attitudes toward Mathematics among Nigerian secondary school students exposed to PBL. Likewise, Ogunsola et al. (2021) reported that PBL enhanced students' academic performance in Mathematics.

Beyond achievement, retention is also a critical indicator of learning outcomes. Retention refers to the ability to remember and reproduce knowledge and skills over time (Hornby, 2000; Obarakpo, 2015). Studies reveal that PBL strategies improve retention. For example, Imotor et al. (2024) demonstrated that Rusbult's Problem-Solving Model significantly enhanced students' achievement and retention in Trigonometry. Similarly, Onyeka, Eze, and Okonkwo (2023) reported higher retention scores among Mathematics students exposed to PBL strategies, while Egara & Mosimege (2023) found that blended learning approaches, which share similarities with PBL, improved retention better than conventional methods.

These findings highlight the need for a paradigm shift from formula-driven, procedural teaching to problem-based approaches that emphasize conceptual understanding, creativity, and real-world applications. To this end, teachers should design PBL lesson plans, develop high-quality problems, and strengthen their facilitation skills. Given the demands of globalization, students must not only master content knowledge but also develop positive attitudes, values, and lifelong problem-solving skills through strategies such as PBL.

Statement of the Problem

There is a growing loss of interest in the study of Mathematics among students in recent times. Among candidates seeking admission into higher institutions of learning, Mathematics is one of the subjects with persistently low enrolment. The case of the Federal College of Education, Odugbo, illustrates this concern. In the 2022/2023 academic session, which was the maiden session of the College, about 500 students were matriculated, yet the Mathematics Department admitted only eight students. Out of this number, five later applied for a change of course, citing lack of interest resulting from weak foundations and low achievement in secondary school, leaving the department with only three students. This trend signals a looming crisis, as society—particularly secondary schools in Apa Local Government Area (LGA)—may soon face an acute shortage of qualified Mathematics teachers. This is alarming given the vital role Mathematics plays in the lives of individuals, the development of society, and global advancement. The consistent poor performance of students in Mathematics at external examinations has further heightened concern, making it imperative for stakeholders in the mathematical sciences to seek lasting solutions. Research-based strategies that enhance students' understanding of Mathematics and boost their confidence in the subject are increasingly being advocated (Awofala et al., 2012). One such approach is the inevitable shift from traditional teacher-centered methods to learner-centered strategies. Against this background, the present study was undertaken to investigate the effect of Problem-Based Learning (PBL) on Senior Secondary School One students' achievement and retention in Mathematics in Apa LGA of Benue State.

Objectives of the Study

The specific objectives of the study are to:

i. Determine the difference in mean achievement scores of students taught mathematics using Problem-Based Learning method and those taught using Conventional Method.
ii. Determine the difference in mean retention scores of students taught mathematics using Problem-Based Learning method and those taught using Conventional Method.

Research Questions

The following research questions guided the study:

i. What are the mean achievement scores of students taught mathematics using Problem-Based Learning method and those taught using Conventional Method?
ii. What are the mean retention scores of students taught mathematics using Problem-Based Learning method and those taught using Conventional Method?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of Significance.

i. There is no significant difference between the mean achievement scores of students taught mathematics using Problem-Based Learning method and those taught using Conventional Method.

ii. There is no significant difference between the mean retention scores of students taught mathematics using Problem-Based Learning method and those taught using Conventional Method.

METHODOLOGY

The study adopted a Quasi-experimental design, involving the pre-test, post-test, non-randomize control group design. This design was used because it is suitable for analyzing gain scores, that is, the difference between pre-test and post-test scores. Quasi-experimental design was used because there was no randomization of subject but intact classes were randomly assigned to groups. The population for the study comprised 40,508 Senior Secondary 1 School Students in Apa LGA of which Multi stage sampling technique was used to select sample size of 150 SS1 students. Data was collected using Mathematics Achievement Test (MAT), and Mathematics Retention Test (MRT) which has reliability index of 0.78. Mean and standard deviation were used to answer the research questions while the Analysis of Co-variance (ANCOVA) was used for testing the hypotheses at 0.05 level of significance.

RESULTS

Research Question one: What are the mean achievement scores of students taught Mathematics using problem-based learning method and those taught using conventional method?

Table 1: Mean Achievement Score and Standard Deviation of Students Taught Mathematics Using Problem-Based Learning Method and Those Taught Using the Conventional Method

Group	Pretest		Posttest		Mean Gain
	$\bar{x}$	SD	$\bar{x}$	SD	
Experimental Group	22.52	6.56	42.35	6.56	19.83
Control Group	17.31	8.14	32.10	10.84	14.79
Mean Difference	**5.21**		**10.25**		**5.04**

In table 1, the mean pre-test score for the experimental group which was exposed to Problem-Based Learning method is 22.52 with standard deviation of 6.56 and the mean pre-test score for the control group which was taught mathematics using the Conventional Method is 17.31 with a standard deviation of 8.14. The mean difference between the pre-test scores of students in the experiment and control group was calculated to be 5.21. This means that before the administration of the test, the students in the experimental group demonstrate higher level of knowledge in mathematics when compared to those students in the control group. Also, the mean post-test scores for the experimental and control groups are 42.35 and 32.10 with standard deviation of 6.56 and 10.84 respectively. The mean difference in their post-test scores is 10.25. However, the mean gain for the experimental group was found to be 19.83 while the mean gain for the control was found to be 14.79. The difference in the mean gain between the experimental and control group is 5.04.

Research Hypothesis One: There is no significant difference between the mean achievement scores of students taught mathematics using Problem-Based Learning method and those taught using Conventional Method.

Table 2: Summary of ANCOVA Result of Students' Achievement by Group

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10435.676[a]	2	5217.838	124.224	.000	.628
Intercept	7037.526	1	7037.526	167.546	.000	.533
PRE_TEST	6599.869	1	6599.869	157.127	.000	.517
GROUP	**1030.124**	**1**	**1030.124**	**24.525**	**.000**	**.143**
Error	6174.518	147	42.004			
Total	215427.000	150				
Corrected Total	**16610.193**	**149**				

a. R Squared = .628 (Adjusted R Squared = .623)

In Table 2, F (1, 147) = 24.525 with p-value of 0.000. Hence $p<0.05$, the null hypothesis is rejected. This implies that, there is a significant difference between the mean achievement scores of students taught mathematics using Problem-Based Learning method and those taught using Conventional Method.

Research Question 2: What are the mean retention scores of students taught mathematics using Problem-Based Learning method and those taught using Conventional Method?

Table 3: Mean Retention Score and Standard Deviation of Students taught Mathematics Using Problem-Based Learning Method and those taught using Conventional Method

Group	Posttest		Retention		Mean Gain
	$\bar{x}$	SD	$\bar{x}$	SD	
Experimental Group	42.35	6.56	45.75	6.32	**3.4**
Control Group	32.10	10.84	32.30	8.15	**0.2**
Mean Difference	**10.25**		**13.45**		**3.2**

Table 3 shows that, the mean post-test scores of students in the experimental and control groups are 42.35 and 32.10 with standard deviation of 6.56 and 10.84 respectively. Also, the mean retention score for the experimental and control group is 45.75 and 32.30 with standard deviation of 6.32 and 8.15 respectively. The mean difference between the retention scores of the two groups

is 13.45. The mean gain for the experimental group is 3.4 and the mean gain for the control group is 0.2. However, the difference in the mean gain between the experimental and control groups is 3.2.

Research Hypothesis 2: There is no significant difference between the mean retention scores of students taught mathematics using Problem-Based Learning method and those taught using Conventional Method

Table 4: Summary of ANCOVA Result of Students' Retention by Group

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8328.489[a]	2	4164.244	94.568	.000	.563
Intercept	5575.969	1	5575.969	126.627	.000	.463
POST_TEST	1721.082	1	1721.082	39.085	.000	.210
GROUP	2636.703	1	2636.703	59.878	.000	.289
Error	6473.085	147	44.035			
Total	230794.000	150				
Corrected Total	14801.573	149				

a. R Squared = .563 (Adjusted R Squared = .557)

In Table 4, F (1, 147) = 59.878 with p-value of 0.000. Hence $p<0.05$, the null hypothesis is rejected. This implies that, there is a significant difference between the mean retention scores of students taught Mathematics using problem-based learning method and those taught using conventional method.

DISCUSSION OF FINDINGS

Findings presented in Table 2 indicate that students exposed to the Problem-Based Learning (PBL) method performed significantly better than those taught using the Conventional Method. Similarly, results from Table 1 affirm that students in the experimental group consistently achieved higher scores compared to their counterparts in the control group. These results corroborate the findings of Ramli et al. (2020), Asanre et al. (2024), and Ogunsola et al. (2021), who also reported that PBL exerts a positive and significant effect on students' achievement in mathematics.

Furthermore, Table 4 reveals that students in the experimental group, who were instructed through the PBL method, demonstrated a superior level of retention ability when compared with those taught using the Conventional Method. This result is further supported by Table 3, which shows

that the experimental group consistently retained mathematical concepts better than the control group.

These findings align with the study by Imotor et al. (2024), who investigated the effect of Rusbult's Problem-Solving Strategy on students' achievement and retention in Trigonometry. Their study revealed a significant difference in mean retention scores between students taught with PBL strategies and those instructed through traditional lecture methods. Similarly, Onyeka, Eze & Okonkwo (2023) found that students exposed to PBL strategies recorded higher retention in mathematics. In the same vein, Egara & Mosimege (2023), who examined the effect of a blended learning approach on secondary school learners, also concluded that innovative, student-centered strategies such as PBL significantly enhance both achievement and retention in mathematics.

CONCLUSION

The study investigated the Effect of Problem-Based Learning Method on Senior Secondary School One Students' Achievement and Retention in Mathematics in Apa LGA, Benue State Nigeria. The study reveals that the Problem-Based Learning (PBL) method significantly improves senior secondary school students' achievement and retention in mathematics in Apa. The findings showed that students taught using the PBL approach achieve higher academic outcomes compared to those instructed through traditional method.

RECOMMENDATIONS

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

i. Mathematics teachers should incorporate PBL methodologies into their teaching to improve students' achievement and retention in mathematics. Training workshops should be organized to equip educators with the necessary skills and techniques to effectively implement PBL in their classrooms.
ii. Schools should be allocated resources to facilitate the use of PBL, including access to instructional materials, technology and collaborative spaces that promote active learning. This support would help create an environment conducive to inquiry-based learning.
iii. Education Authorities should consider integrating PBL approaches into the national curriculum for mathematics and other subjects, recognizing its potential to improve students' learning outcomes. This integration would encourage schools to adopt innovative teaching methods.

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