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EFFECTS OF PROBLEM-BASED LEARNING APPROACH ON SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT IN GEOMETRY, IN ENUGU STATE, NIGERIA

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Abstract
This study investigated the effects of Problem Based Learning (PBL) approach on secondary school students' academic achievement in Geometry. Quasi-experimental design was adopted in the study. Pretest-posttest, non- equivalent control group was used. Four intact classes, two of which were randomly assigned to experimental and the other two to control groups were used for the study. The sample of the study consisted of 140 SSII students from government owned coeducational secondary schools in Enugu Education Zone. Two research questions and two hypotheses guided the study. Geometry Achievement Test (GAT) was used for data collection. The reliability coefficient of GAT was 0.72. GAT was constructed by the researcher and validated by three research experts. Mean and standard deviation were used to answer the research questions while the hypotheses were tested at .05 level of significance using Analysis of Covariance (ANCOVA). Experimental groups were taught using Problem Based Learning (PBL) approach while control groups were taught the same topics using expository method. Major findings of the study revealed that students taught Geometry with PBL approach achieved higher than those taught with expository method. The result also showed that male and female secondary schools' student did not differ significantly in their achievement. It was recommended that Mathematics teachers should adopt PBL for teaching mathematic especially geometry in senior secondary school.

***Keywords**: Problem-Based Learning Approach, Academic Achievement, Geometry.*

Introduction

Mathematics is one of the most important subjects in the school curriculum. Imoko and Isa (2015) posited that Mathematics provides the bedrock and foundation for creative thinking and cognitive development and should, therefore, be emphasised early in the academic life of the nation's citizenry.

Geometry is the aspect of mathematics which deals with the study of different shapes. These shapes may be plane or solid. A plane shape is a geometrical form such that straight line that joins any two points on it wholly lies on the surface. A solid shape on the other hand is bounded by surface which may not wholly be represented on a plane surface (Adolpaus, 2011). It is concerned with properties of space that are related with distance, shape, size, and relative position of figures. Geometry is regarded as "a unifying topic in the entire mathematics curriculum and it is a rich source of visualization for arithmetical, algebraic, and statistical concepts" (Tsoho, 2011). Geometry is found everywhere: in art, architecture, engineering, robotics, land surveys, astronomy, sculptures, space, nature, sports, machines, cars and much

more and hence, tagged the bedrock of engineering and technological development (Adolphus, 2011, Bolaji, Kajuru & Timayi, 2015). Geometry is important for everyone.

Despite the remarked, deficient performance of students in geometry is a great concern. Ayotola and Ishola (2013) asserted that the incessant low performance of students in secondary school mathematics and the reduction in numbers of students who show interest in answering geometrical questions especially in the Senior Secondary School Certification Examination (SSSCE) call for closer look into how the topic (geometry) is taught. It is common knowledge that many students do not assimilate the mathematical concepts taught in schools due to the type of instructional strategy used by the teacher. Oloruntegbe and Omoifo (2018) asserted that the success of teaching and learning depend on the type of instructional strategy adopted by the teacher. This simply implies that teaching method has a great role to play when it comes to students' achievement in mathematics. Ajaegbe & Ekwueme (2019) pointed out that presenting geometry in a way that stimulates curiosity encourages exploration that can support learners' intuition; thus enhancing communication, students' learning and achievement in mathematics. Based on this, the researcher decided to embark on a study to determine the effect of Problem-Based Learning (PBL) strategy on secondary school students' achievement in Geometry.

Theoretically, PBL is based on constructivism and its approach to instructional design is based on problem solution and 'contextual learning' (Nese 2014). According to Nneji (2012), in constructivist terms, learning depends on the way each individual learner views a particular situation and draws his or her own conclusion. Constructivist teaching practices in science and mathematics classrooms are intended to produce much more challenging in instructions for students and thus, produce improved meaningful learning.

Problem-Based Learning (PBL) is an instructional strategy in which learning is anchored on real world problems rather than on particular subject areas.

Nilson (2010) asserted that Problem-based learning (PBL) is a student-centered approach in which students learn about a subject by working in groups to solve an open-ended problem. This problem is what drives the motivation and the learning. PBL is significantly more effective than traditional instruction to train competent and skilled practitioners and to promote long-term retention of knowledge and skills acquired during the learning experience (Strobel and Van, 2013).

To improve the academic achievement of students in Mathematics, a more engaging teaching strategy should be employed by the teacher. Among these strategic teaching methods is the Problem based Learning (PBL) approach. This paper focuses on problem-based learning as a teaching strategy and how it can affect students' achievement in mathematics. The research specifically assesses the effects of PBL as a method of instruction on senior secondary school students' achievement in geometry.

PBL as a student-centred pedagogical learning involves students put into smaller group to discuss a challenging problem with the aim of finding solution to the problem. Most teachers have been conversant with the traditional method and efforts to modifying it have not been easy. The teacher plays a key role in the PBL instructional process and that the teacher should adopt to new ideas and strategies other than the traditional method, which demotivates the student's abilities in the inquiry process. In the implementation of PBL the students are given a complex problem to solve and the necessary guidelines that will assist them in solving it (Alfred, David and Abayomi, 2013). The students work in smaller groups to critically discuss the problem and possible ways of exploring and reflecting the problem as well as the content.

Strobel and Van,(2013) explained that students in a PBL classroom try to look for information, access learning material and share ideas among themselves while working in small groups. One of the roles of the teacher is to guide the students through questioning that will direct the students to find possible solution to the problem. The students in the group go through several steps to solve the problem through observations, predictions and drawing conclusions based on assumptions (Bell, 2010). Goodnough (2006), in implementing PBL suggested that the students should be asked open-ended questions that relates to the problem, find possible solutions through problem-solving activities, analyse data using the guided questions, and finally assess problem solving skills and critical thinking skills of students as a way of knowing how much knowledge students have acquired.

Problem-based learning (PBL) is an instructional practice that requires students to work together to solve problems. This method is designed to engage all learners, even those who typically struggle. PBL is a model that relies on students to think deeply and be cooperative learners (Zakaria & Iksan, 2007). In PBL classroom, students are encouraged to perform active interactions within their group members where students explained their reasoning when solving the problem. Once the students understand the context of the problem they are asked to identify the statement of the problem such as, what information is given, and what information is needed. The students are admonished to go home after school to perform the task through assessing multiple resources such as textbook and notebook. During the next lesson, the students will collaboratively analyse all the gained information and produce a draft on their approach and methods in solving the problem. At this stage, the students also evaluate their group members' findings and decided the best possible approach and methods to solve the given problem.

In PBL strategy, learning begins with a problem to be solved, and the problem is posed in such a way that students need to gain new knowledge before they can solve the problem. Rather than seeking a single correct answer, students interpret the problem, gather needed information, identify possible solutions, evaluate options, and present conclusions (Kyeong, 2003.Proponents of PBL believe that when students develop methods for constructing their own procedures, they are integrating their conceptual knowledge with their procedural skill. Below are the steps taken during the Problem based learning lesson.

Step 1: Introduction, Understand the Problem, and Searching for Information

- Students are introduced to understand and analyse the given problem.
- Students make inquiries and perform searches individually or collaboratively to gain understanding of the problem.
- Teacher monitors students' progress and make sure that they are on the right track.

Step 2: Construct and Gather Solution

- Students gather all the necessary information, and discuss to produce a draft of their possible solutions to solve the given problem.

Step 3: Presentation and Reflection

- Students prepare for a 5-7 minutes presentation to share their findings in front of the whole class.
- Teacher checks that students have completed their work and asks students additional questions upon closure of PBL session.

Gender issue in sciences generally and mathematics in particular is indeed of a great paramount important. Due to the inconsistency on the result of effect of gender and students' poor achievement in mathematics, the researcher investigated the interaction between teaching strategy and students' gender as it affects their achievement in Geometry with an aim to correct some gender-based misconceptions in teaching and learning of Mathematics.

Purpose of the Study

The purpose of this study was to investigate the effect of Problem Based Learning (PBL) on secondary school students' achievement in Geometry. Specifically, the study investigated the;

1. Effect of PBL on Senior Secondary II (SSII) students' achievement in geometry.
2. Effect of PBL on Senior Secondary II (SSII) students' achievement in geometry with regards to their gender.

Research Questions

1. What is the difference in the mean achievement scores of students taught geometry with Problem-Based Learning approach (experimental group) and those taught with expository approach (control group)?
2. What are the mean achievement scores of male and female students taught geometry using Problem-Based Learning approach (PBL)

Research Hypotheses

1. There is no significant difference in the mean achievement scores of students taught Geometry using the Problem-Based Learning approach and those taught with the expository method.
2. There is no significant difference between the mean achievement scores of male and female students taught geometry using Problem-Based Learning approach (PBL)
3. There is no significant interaction effect between the teaching method and gender on students' achievement scores in Geometry.

Research Method

The design of this study was non-equivalent quasi-experimental research. The study was conducted in Government owned secondary schools in Enugu Education Zone of Enugu State. The population of the study was four thousand five hundred and sixty seven (4567) senior secondary two students. Simple random sampling technique was used to sample two (2) out of fifteen (15) coeducational schools in the zone. The sample size of the study was one hundred and forty (140) senior secondary II (SSII) students in the two sampled schools in the Zone. Furthermore, from the two schools so sampled, the researcher used simple random sampling technique to sample four (4) SSII intact classes, two from each school and consequently assigned them to experimental and control groups randomly.

The instrument used for data collection was Geometric Achievement Test (GAT) and it was developed by researchers. GAT was made up of five (5) items of essay test (open-ended) questions. These types of questions allow students to find possible solutions through problem-solving activities, and involve critical thinking skills as a way of knowing how much knowledge they (students) have acquired. The GAT instrument was face and content validated by three research experts. After necessary corrections as directed by the experts, GAT was

administered to 73 SS2 students in a different school outside the schools sampled for the study, the scores obtained were used to obtain the reliability coefficient of 0.72 using Cronbach alpha. Data were collected after the post-test, the research questions were analysed using mean and standard deviation whereas the null hypotheses were tested using the Analysis of Covariance (ANCOVA).

Results and Interpretation

Research Question 1: What is the difference in the mean achievement scores of students taught geometry with Problem-Based Learning approach and those taught with conventional approach?

Table 1: Achievement scores of students in the experimental and control groups

Group	N	Pre-GAT		Post-GAT		Mean Gain	Mean Diff.
		Mean	S. D	Mean	S.D		
Experimental	78	18.10	1.83	69.10	3.05	51.00	21.54
Control	62	19.23	1.65	40.77	3.74	21.54	

** N=Number of Subjects, S.D= Standard Deviation, GAT= Geometry Achievement Test

Table 1 showed that the mean achievement score of the experimental group in pre-GAT was 18.10 with standard deviation of 1.83, while that of the control group was 19.23 with standard deviation of 1.65.

In the post-GAT, the mean achievement score for the experimental group was 69.10 with standard deviation of 3.05, while the mean for the control group was 40.77 with standard deviation 3.74. Also, the difference in the mean gain scores of both groups was 21.54.

Research Question 2: What is the mean achievement scores of male and female students taught geometry using Problem-Based Learning approach (PBL)

Table 2: Achievement scores of male and female students in pretest and post test

Gender	N	Pre GAT		Post GAT		Mean diff.
		Mean	S.D	Mean	S.D	
Male	34	18.56	2.16	67.82	2.58	3.08
Female	44	17.75	1.45	70.09	3.05	

From Table 2 above, the pretest mean achievement scores and standard deviations were 18.56 and 2.16 for male students and 17.75 and 1.45 for female students respectively. Similarly, the posttest mean achievement scores and standard deviations were 67.82 and 2.58 for male students and 70.09 and 3.05 for female students. Apparently, there was no tangible difference as the standard deviations were very low for both groups, and hence both means were reliable as the mean difference was 3.08.

Hypotheses

Ho_1: There is no significant difference in the mean achievement scores of students taught Geometry using the Problem-Based Learning approach and those taught with the expository method.

Table 3: Analysis of Covariance (ANCOVA) result of mean achievement scores of students taught Geometry using PBL approach and expository method.

Source of Variance	Type III Sum of Squares	Df	Mean Square	F-calc.	P-value	Decision
Corrected Model	27734.269[a]	2	13867.135	1217.605	.000	
Intercept	3209.868	1	3209.868	281.843	.000	
PRETEST	13.744	1	13.744	1.207	.274	
GROUP	25497.058	1	25497.058	2238.772	.000	S
Error	1560.274	137	11.389			
Total	477114.000	140				
Corrected Total	29294.543	139				

a..R Squared = .947 (Adjusted R Squared = .946)

The result above showed that the F-calculated for the group which was the main effect gave 2238.772 and was significant at 0.000. Since 0.000 was less than 0.005, this means that at 0.005, the f-value was significant. Therefore, hypothesis one was rejected. Hence, the study concluded that there was significant difference between the mean achievement scores of students that were taught Geometry using Problem-Based Learning approach and those students taught using expository methods.

HO_2: There is no significant difference in the mean achievement scores of male and female students taught geometry using Problem-Based Learning approach (PBL).

Table 4: ANCOVA of Achievement scores of male and female students taught geometry using Problem-Based Learning approach (PBL)

Source of Variance	Type III Sum of Squares	df	Mean Square	F-calc.	P-value	Decision
Corrected Model	2768.059[a]	2	1384.030	7.148	.001	
Intercept	13016.035	1	13016.035	67.223	.000	
PRETEST	2707.487	1	2707.487	13.983	.000	
GENDER	530.849	1	530.849	2.742	.100	NS
Error	26526.483	137	193.624			
Total	477114.000	140				
Corrected Total	29294.543	139				

a..R Squared = .094 (Adjusted R Squared = .081)

Table 4 revealed that Gender (Male and Female) gave an F-value of 2.742 and was not significant at 0.100. Since 0.100 was not less than 0.05, the null hypothesis 2 was not rejected as stated. Hence, the study concluded that there was no significant difference in the mean

achievement scores of male and female students taught geometry using Problem-Based Learning approach (PBL).

HO_3: There is no significant interaction between the teaching method and gender on students' achievement scores in Geometry.

Table 5: ANCOVA on Interaction between the teaching method and gender on students' achievement score

Source of Variance	Type III Sum of Squares	Df	Mean Square	F-calc.	P-value	Decision
Corrected Model	28170.869[a]	3	9390.290	1136.522	.000	
Intercept	409756.141	1	409756.141	49593.432	.000	
Group * Gender	28170.869	3	9390.290	1136.522	.070	NS
Error	1123.674	136	8.262			
Total	477114.000	140				
Corrected Total	29294.543	139				

a..R Squared = .962 (Adjusted R Squared = .961)

From the results in table 5 above, it was observed that Groups * Gender gave an f-value of 1136.522 and was not significant at 0.070. Since the P-value is greater than 0.05, the null hypothesis 3 is not rejected. Thus, there is no statistical difference in the interaction between the teaching method and gender on students' achievement scores in Geometry.

Discussion of Findings

The results of this study supports the recommendations of Oloruntegbe and Omoifo (2018), who asserted that the success of teaching and learning depends on the type of instructional strategy adopted by the teacher. The findings of this study revealed a significant difference in the achievements of students in both groups in favour of the experimental group. This result is in agreement with the research findings of Alfred, David and Abayomi (2013) who reported the effectiveness of problem based learning in teaching and learning.

The students' better academic achievement could be attributed to the strategy adopted in using problem based learning approach where the students were actively involved and had control over their learning during the instruction period.

The result of the study further revealed that there is no significant influence of gender on students' achievements in mathematics. Therefore, the findings of this study had shown that gender has no significant influence on students' achievement in mathematics using Problem based learning instructional approach. The findings of this study is in agreement with Adulphus (2011), Nneji (2012), Tsoho (2011) that there is no significant effect or interaction between teaching method, gender of students and students' achievement in mathematics. This simply suggests that Problem Based Learning instructional approach can be used at all levels of education and provides quality education for all and also creates equal opportunity for all irrespective of gender.

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