

Effects of Problem-Based Learning on Junior Secondary II Students' Achievement in Algebra in Bauchi Metropolis

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Abstract

This study investigated the effect of the problem-based learning (PBL) approach on Junior Secondary II students' achievement in Algebra in Bauchi Metropolis, Nigeria. A quasi-experimental design with a pretest-posttest control group was employed. The study involved 80 students selected from a total population of 658 Junior Secondary II students across two schools in Bauchi Metropolis. Purposive sampling was used to select 20 schools, and two schools were randomly assigned to the experimental and control groups. The experimental group received Algebra instruction using the PBL approach, while the control group was taught using traditional methods. Data were collected through the Algebra Achievement Test (AAT), administered as both a pretest and posttest. The data were analyzed using descriptive statistics (mean scores and standard deviations) to answer the research questions, while ANCOVA was used to test the hypotheses at a 0.05 significance level. The findings indicated that the PBL approach significantly improved students' achievement in Algebra. It is recommended that Algebra teachers incorporate the PBL approach in their teaching practices to enhance student learning.

Keywords: Problem-based learning approach, Algebra, Junior secondary II students, Academic achievement and Bauchi metropolis.

Introduction

Globally, attempts are being made by educators and other stakeholders in education to ensure that students learn without difficulty. These attempts are being made bearing in mind that weak performance by students can mar the expectations that educated citizens are the pride of any nation. The history of education is full of efforts to make learning more active, effective, and productive. However, to date, some of the challenges to effective learning still persist (Adegbemile, 2019). An aspect of education that is so vital to the development of any nation is science education. Science, as it is generally believed, is the bedrock on which technological

advancement is built. According to Usman (2018), science involves intellectual activities engaged in by humans to discover the natural world they live in. Therefore, it is an indispensable tool leveraged for advancement by both developed and developing nations of the world (Feynman, 2019). The aspect of science that is of concern in this study is Mathematics. Due to its central role in education, in Nigeria Mathematics is considered a compulsory subject that must be taken and passed at both the primary and secondary school levels.

Algebra is a fundamental branch of mathematics that plays a crucial role in developing students' problem-solving skills, logical reasoning abilities, and critical thinking capabilities. However, it is often perceived as a challenging subject by students at the junior secondary level. In the educational context of Bauchi metropolis, fostering interest and achieving proficiency in algebra among Junior Secondary II students is of paramount importance to ensure a strong foundation for their future mathematical learning and academic success. Traditional instructional methods in teaching algebra often rely heavily on rote memorization of formulas and procedures, which may hinder students' understanding and engagement with the subject. Therefore, there is a need to explore alternative teaching approaches that can foster students' interest, enhance their achievement, and promote a deeper understanding of algebraic concepts. One such approach is problem-based learning (PBL), which is centered on authentic, real-world problems that stimulate students' curiosity, critical thinking, and problem-solving skills. PBL allows students to actively engage in the learning process by investigating and solving meaningful problems, thereby promoting a deeper understanding of algebraic concepts and their applications. This study aims to fill this gap by investigating the effect of the problem-based learning approach on students' interest and achievement in algebra. By identifying how the implementation of problem-based learning influences students' attitudes, motivation, and performance in algebra, this research seeks to provide valuable insights and recommendations for educators, curriculum developers, and policymakers to enhance the teaching and learning of algebra in Bauchi metropolis. Some of the factors responsible for students' poor performance in Mathematics among secondary school students have been identified. Among these challenges, teachers' factors, such as teaching methods and poor content knowledge. Furthermore, inadequate of relevant and updated textbooks, Mathematics laboratory, poor motivation on the part of both teachers and students and poor teaching methods, on which all others rest on. Teachers' continued use of traditional or conventional approach in teaching Mathematics has affected students negatively for a long time. The traditional or conventional teaching method is a strategy in which students passively absorbed what the teacher says. This approach has not been favoured by many and has been criticized for being lecture-based instruction and teacher-centred instructional methods (Zakaria & Iksan, 2017). Modern methods of teaching Mathematics have shifted from conventional method to Students-centred learning which also affords them active participation in their learning processes and the teacher is merely a facilitator of learning and remains the focal point of contemporary Mathematics education. Hence, active learning involves learners taking responsibility for their learning and being given the opportunity to make decisions about various aspects of their learning process for self-regulation. problem-based learning (PBL) was chiefly developed from Barrow's problem-based learning model. The PBL was developed by Barrows for medical students at McMaster University in the early 1970s by creating scenarios where students could apply learnt skills to a real-life problem-solving scenario (Tarmizia, Ahmad & Bayat, 2019).

This study also considers gender and quantitative ability as moderating variables reported as factors affecting performance in Mathematics. Omosewo (2018) reported no significant

difference in the academic performance of male and female students in Mathematics. Male and female students need encouragement to make use of hands-on and heads-on senses. These skills are required in the problem-based learning approach. The male students taught using PBL did not significantly perform better than female students taught using the same method (Etiubon & Ugwu, 2019).

Achievement according to American Heritage Dictionary (2016) is that level of accomplishment evaluated by teachers, tests etc, in order words, definition of achievement depends upon value judgment, opinions and standards. Therefore achievement is basically an act of accomplishing or finishing something, something accomplished successfully especially by means of exertion, skill, practice or perseverance. According to Kani and Ezeodo (2022) achievement is the aspect of measuring the effects of relatively standardized sets of experiences. Achievement, simply put, is accomplishing whatever goals one sets for him/herself, not necessarily earning a lot of money. In the context of this work, academic achievement is the focus. According to Mkpaoro and Ezeudu (2016) academic achievement could be seen as the level of proficiency and knowledge demonstrated by an individual after learning has occurred. The parameter for verifying the extent of learning that has occurred or the level of proficiency of an individual is a teacher-made test, examination or standardized tests. The parameter for verifying the extent of learning that has occurred or the level of proficiency of an individual is a teacher-made test, examination or standardized tests. Johnson and Iweka (2019) stresses that, the yard sticks for measuring one's academic achievement is assessing the academic performance of the individual through tests and systematic observation. Academic achievement can be described as high or low.

When academic achievement is measured, one can observe it as being high when a child excels and performs extra-ordinarily well in his/her academic activities by scoring high marks. But when a child performs poorly in his/her academic activities by scoring very low marks, academic achievement is said to be low. It is worthy of note that without a strong desire/will, one will not believe, and therefore will not achieve. Johnson (2019) supports the above assertion by identifying “the will to achieve and the ability to achieve as the two major factors that can affect academic achievement. If a person is willing to achieve something, he has to work on his ability and improve on it by dedicating more time and energy to the thing. Buttressing this point, Mkpaoro and Ezeudu (2016) asserts that achievement equals aptitude and experience, putting it in an equation; $Achievement = Aptitude \times Experience$.

The measurement of academic achievement is focused on the past performance of the pupils/students. Hence the students' academic achievement level is measured based on the test/examination scores on the particular subject already studied. This score is the product of the students' ability and experiences gained by the students during the processes of teaching by the teacher. The result or outcome of academic achievement serves a lot of purposes. It is very essential in determining a lot of things that surround the student and even the educational programme. The present study was designed to explore the effects of mathematics language and students' attitude on junior secondary tow students' achievement in mathematics in Bauchi metropolis, Nigeria. The researcher therefore, would want to find out if there is a relationship between the knowledge of problem-based learning approach and achievement of students in Algebra and the relationship between the students' interest towards mathematics and their achievement in the subject in Bauchi metropolis.

In spite of the great emphasis placed on the study of mathematics and the huge investment in it, it can be said without any fear of contradiction that all is not well with its teaching and

learning. Nwoke and Ugwuegbulam (2016) asserted that no teacher in Nigeria concerned with the teaching of mathematics at any stage, from infants upwards and particularly at secondary school level can honestly say to himself that all is well with the teaching of the subject. She further pointed out that the state of mathematics in the country is appalling as the subject is disliked by many students in spite of its utility.

Algebra is a critical component of mathematics education, but many Junior Secondary II students in Bauchi metropolis, Bauchi state struggle with low interest and achievement in this subject. Traditional instructional methods often rely on rote memorization and procedural approaches, which may not effectively engage students or promote deep understanding. To address this issue, problem-based learning (PBL) has emerged as a potential instructional approach that promotes active engagement, critical thinking, and problem-solving skills. The concern expressed by parents, teachers and other interest groups on how to improve student's achievement in mathematics in school in Bauchi state informed the decision of this researcher to investigate whether problem-based learning approach might influence their interest and achievement in algebra in junior secondary II in Bauchi metropolis. To this effect, the study investigates the effect of problem-based learning approach on junior secondary II students' interest and achievement in algebra in Bauchi metropolis, Bauchi state.

The aim of this study is to determine the effect of problem-based learning approach on junior secondary II students' interest and achievement in algebra in Bauchi metropolis of Bauchi state, Nigeria. Specifically, the objectives of the study are to:

1. Examine the extent to which students' achievement in Algebra differs when taught using PBL compared to the conventional lecture method.
2. Establish the relationship between the achievement scores of male and female students taught using PBL.

Research Questions

Based on the objectives of the study as stated, the following research questions will be asked to guide the study:

1. What are the differences in achievement scores of students in algebra when taught using problem-based learning approach and conventional approach?
2. What are the extents of difference in achievement scores of male/female students in algebra when taught using problem-based learning approach and conventional approach?

Hypotheses

The following null hypotheses were formulated and each will be tested at an alpha level of 0.05.

1. There is no statistically significant difference between the mean achievement scores of students taught algebra using problem-based learning approach and those taught using conventional approach.
2. There is no statistical significant difference in the mean achievement score of males and females taught using problem-based learning approach and those taught, using conventional approach.

Methodology

This study employed a quasi-experimental design, specifically a non-equivalent pre-test and post-test design. This design involved selecting two intact classes, with one serving as the experimental group and the other as the control group. The quasi-experimental research design was utilized

because it enabled the use of intact classes, thereby avoiding disruption to the existing classroom arrangements.

The population for this study consisted of 80 public junior secondary schools in Bauchi Metropolis, with a total of 14,828 JS II students. Public junior secondary schools were preferred for this study due to their uniform curriculum and centralized administration style, which provided a convenient and consistent sample.

A sample of two junior secondary schools was selected from the 80 schools in Bauchi Metropolis. The selected schools were Junior Secondary School Sabon-Kaura (School A) and Junior Secondary School Birshin-Fulani (School B). School A had a total of 230 JS II students, comprising 158 boys and 72 girls, with 62 students selected for the experimental group. School B had a total of 426 students, comprising 210 boys and 216 girls, with 56 students selected for the control group. The purposive sampling technique was used to select 20 junior secondary schools from the 80 schools in Bauchi Metropolis. Subsequently, a simple random sampling technique was employed to select two schools for the study.

The research instrument for this study is “Algebraic Achievement Test (AAT)”. The Algebraic Achievement is a 40 multiple choice item developed by the researcher from the content area used in JS 2 curriculum. This instrument is used as pretest, to assess student’s entry behavior on Algebra. The same instrument will be used at the end of the instruction as post-test for the purpose of measuring the level of their achievement in Algebra. Face and construct validity was established for the instrument. On the mathematics teacher made test, the test –re-test method was used to establish the reliability. The test was administered on two intact classes in Junior Secondary School Miri and Junior Secondary School Gwallameji both Schools are within the stipulated population, but outside the research sample. The scores gathered from that test were recorded. After two weeks, the test was repeated on the same group, the result of which was collected, recorded and correlated. The reliability coefficient obtained was 0.85 which was accepted by the researcher and that proved the reliability of the algebraic achievement test.

Results

Research Question One

What are the differences in achievement scores of students in algebra when taught using problem-based learning approach and conventional approach?

Table 1

Pretest and posttest Achievement of students on Algebra for the Experimental and Control Groups.

Group	N	Before Mean	SD	After Mean	SD	Mean Gain	$\bar{x}$ - difference
Experimental	62	37.48	13.48	69.89	16.50	32.41	28.38
Control	56	35.38	11.67	39.41	14.72	4.03	

Table 1 reveals the pre-test and post-test achievement mean score of students taught algebra using problem-based learning approach and those taught without. From the result, in the experimental group the post-test mean score ($\bar{x}$ = 69.89, SD = 16.50) was higher than the pre-test mean score ($\bar{x}$ = 37.48, SD = 13.48) with a mean gain of 32.41, indicating that there was improvement in the achievement of students after treatment. Also, for the control group the mean score was 35.38 and a standard deviation of 11.67 at the pretest. However, in the post- test the mean score of students increased to 39.41, SD = 14.72. The findings show that students in the experimental group had a higher mean score (69.89) after exposure to problem-based learning approach, than those in the control group (39.41) who were not given treatment with a mean difference of 28.38. The pre-test scores for both groups were relatively low, but after the intervention the experimental group performed better than the control group. It can be deduced that exposure to problem-based learning approach do improve students' achievement in algebra.

Research Question Two

What are the differences in achievement scores of male/female students in algebra when taught using problem-based learning approach and conventional approach?

Table 2: Result of Post-test Achievement of Male and Female Students in Algebra for the Experimental Group.

Group	Gender	N	Pretest $\bar{x}$	SD	Posttest $\bar{x}$	SD	Mean Gain	$\bar{x}$ Diff
Experimental	Male	40	35.18	12.94	68.75	16.82	33.57	3.3
	Female	22	41.68	13.71	71.95	16.09	30.27	

Table 2 shows the result of the pre-test and post-test achievement mean scores of male and female students in the experimental group, The pre-test mean scores for experimental group was 35.18 and a standard deviation of 12.94 for male students while the females had a mean of 41.68 and standard deviation of 13.71 before treatment. The table recorded a post-test mean score of 68.75 and a standard deviation of 16.82 for male, while the female recorded a post-test mean score of 71.95 and a standard deviation of 16.09. The result indicates that the mean gain score of male students is 33.57 and that of female students is 30.27 with a mean difference of 3.3 this implies that

female students perfumed slightly better than their male counterparts in algebra when taught using problem-based learning approach.

Hypotheses Testing

Hypothesis one

There is no statistically significant difference between the mean achievement scores of students taught algebra using problem-based learning approach and those taught using conventional approach.

Table 3: ANCOVA Result on Posttest Achievement Mean Score of Experimental and Control Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	32052.518 ^a	2	16026.259	77.417	.000	.574
Intercept	16453.104	1	16453.104	79.479	.000	.409
Pre – achievement	4723.467	1	4723.467	22.819	.000	.166
Group	25276.514	1	25276.514	122.102	.000	.515
Error	23806.296	115	207.011			
Total	418330.000	118				
Corrected Total	55858.814	117				

a. R Squared = . 574 (Adjusted R Squared = .566)

Analysis of Covariance (ANCOVA) was conducted to determine if a significant difference, exists in the posttest achievement of students in algebra in experimental and control groups. Table 5 shows that $F(1,15) = 122.10$, $p < 0.05$, partial $\eta^2 = .515$, since the p - value of 0.000 is less than 0.05 level of significance, the null hypothesis was rejected, indicating that there was a significant effect of problem-based learning approach on students' achievement in algebra. 56.6% of the variation in achievement is explained by the treatment, while the remaining is due to other factors not included in this study. Hence, we can say that problem-based learning approach can help improve students' achievement in algebra.

Hypothesis two

There is no statistical significant difference in the mean achievement score of males and females taught using problem-based learning approach and those taught, using conventional approach.

Table 4: ANCOVA Result on Posttest Mean Achievement Score of Experimental Group in Algebra based on Gender

Source	Type III Sum of Squares	df	Mean Square	F	P-value	Partial Eta Squared
Corrected Model	256.745 ^a	2	128.373	.463	.632	.015
Intercept	27806.846	1	27806.846	100.28	.000	.630
Pre – test	110.990	1	110.990	86.255	.529	.007
Gender	86.255	1	86.255	277.279	.579	.005
Error	16359.464	59	277.279			
Total	319437.000	62				
Corrected Total	16616.210	61				

a. R Squared = .010 (Adjusted R Squared = -.094)

The data were subjected to analysis of covariance (ANCOVA) having male and female students in the experimental group. The main effect of male yielded ($\bar{x}$ 68.75; SD = 16.82) and female ($\bar{x}$ = 71.95; SD = 16.09); $F(1, 59) = .311$, $P > 0.05$, partial $\eta^2 = .005$. Since the p-value of 0.579 is greater than the 0.05 level of significance, the null hypothesis was retained. This indicates that the achievement of male students in Algebra do not significantly differ from those of female students. It means that students' achievement in Algebra is not affected by gender.

Discussion

The result in table 1 shows the achievement of male and female students in Algebra in the experimental group. At the pre-test the female got higher mean score as well as higher standard deviation than their male counterpart in the experimental group likewise in the post-test result, the female students recorded higher mean score and higher standard deviation than the male students. This implies that female students performed slightly better than their male counterparts in Algebra when taught using problem-based learning approach.

Based on the analysis of covariance (ANCOVA) results on the problem-based learning approach and students' achievement toward Algebra in respect to their achievement as indicated in table four. The results proved that the null hypotheses were retained in other words, they are accepted, this implies that there is no significant difference in the mean achievement of male and female students in Algebra after exposed to treatment and also there is no significant difference in the mean achievement score of male and female students in Algebra after exposed to treatment.

Conclusion

From the findings of this study, it was discovered that students achieve better in algebra if they are exposed to problem-based learning approach in Bauchi metropolis. Moreover, the findings also indicate that female students performed slightly higher than their male counterparts in algebra when taught using problem-based learning approach. The study concluded that teaching algebra using the problem-based learning approach is an effective method. Students achieve higher mean scores in algebra when exposed to problem-based learning approach.

Recommendations

The following recommendations were made based on the findings of the study:

1. Employers should train mathematics teachers that would teach algebra effectively.
2. Mathematics teachers should be encouraged to attend seminars and workshops where new methods and approaches to teaching algebra are promoted so as to advance beyond the traditional methods of instruction.
3. Provision of fully equipped mathematics laboratories in schools with relevant teaching materials that would help the students to understand algebra effectively.

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