



Effects of Problem-Based Learning on Students' Academic Algebra Performance in Uyo Local Government Area, Akwa Ibom State, Nigeria

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Abstract

The study looked into how well students in Uyo, Nigeria, learned algebra using the Problem-Based Learning approach. Three research questions and three hypotheses were used to guide the study. Quasi-experimental design was used. 3,173 Junior Secondary One (JS1) students constituted the population, and sample of 124 students. Three professionals (mathematics lecturers and teachers) validated developed instruments for data collecting tagged Mathematics Achievement Test (MAT). The instrument's reliability was 0.73. The mean, standard deviation, and Analysis of Covariance (ANCOVA) with a 0.05 level of significance level were used to analyse the study's data. Gender findings on achievement of students was not statistically significant while Problem-Based Learning method (PBL) had significant effect on achievement of students. According to the findings, it was recommended, that math teachers embrace the PBL technique in the classroom to improve students' proficiency with algebraic operations.

Keywords: Interactive Effect, Problem Based Learning (PBL), Academic Achievement, Algebra.

Introduction

Algebra is a fundamental branch of mathematics that uses symbols and other letters to show relationships or properties of quantity. It is one of the main branches of pure mathematics and focuses on the study of operations, constructions, relations, and the concepts that result from them, such as terms, equations, polynomials, and algebraic expressions. A key component of the mathematics curriculum is algebra, which includes substitution, factoring, problem-solving, and graphing. Since algebra is a crucial component of the mathematics curriculum, according to Laughbaum (2017), it frequently acts as a gateway to achieving success in secondary school, post-secondary education, and a variety of job routes, opening up opportunities for a better quality of life and a higher income.

Algebra is necessary for students to understand and have the mathematical skills needed for problem-solving, communicating, thinking, and connecting in daily life. This is accurate because algebraic language is used to express most mathematical ideas. The way algebra is taught in secondary schools has not changed considerably over time. For the purpose of laying the groundwork for next mathematics and scientific studies at the higher level, algebra is presented in the junior secondary school level (Adenegan, 2013). It has been suggested that introducing linear algebraic expression to students gradually in the early grades may help them grasp the idea.

Studies conducted in Nigeria show that poor achievement of students in linear algebraic expressions is the main reason for failure in mathematics, especially at junior secondary schools (Banerjee and Subramaniam, 2012; James and Adewale, 2015; Salmiza and Muhamad, 2016; Marilou and Charita 2022). Learning of linear algebraic expression requires the students to actively participate in constructing knowledge, which could lead to creativity and high cognitive reasoning. This happens as a result of students not learning and comprehending how to solve algebraic problems; instead, they simply memorize solutions that teachers have already explained. According to Radford (2012), one of the most poorly understood, despised, and badly taught algebraic concepts in Nigeria's junior secondary schools is linear algebraic expressions.

The expository method of teaching linear algebraic expression has been found to prevent students from actively participating in the class and creating their own mathematical knowledge because it is teacher-centered. This is a problem with teaching and learning of linear algebraic expression because the majority of teachers still adhere to the old system of teaching that has nothing interesting or enjoyable to offer to the learners (Ladele, 2013). Another issue is the lack of application of the concepts being taught in real-world contexts. This makes pupils passive recipients who are not challenged to think mathematically. Few opportunities are provided for children to independently discover the capabilities and power of algebra.

The lecturers' explanation style had a detrimental impact on effective learning at different educational levels (Adu & Olaoye, 2015). They noticed that from 2002 to 2010, more than 89% of the teachers who participated in National Mathematical Centre (NMC) workshops primarily used the expository approach of instruction. In Nigeria, students are meant to memorise rules and procedures of solving mathematical problems. Teachers in most cases briefly does their introduction and textbooks questions are picked and answered. This always leads students to believe that mathematics, like other courses or themes, is something they can not really understand. This has led to students' underachievement in algebra (Adu & Olaoye, 2015). Expository instruction starts with the grammatical norms of algebra, presenting students with a given symbolic language that is unrelated to any real object or event.

In Nigeria, faculties of education and some of their departments, state and federal ministries of education, organizations like the Teachers Registration Council of Nigeria (TRCN) and the Universal Basic Education (UBE) board, the Mathematical Association of Nigeria (MAN), and science teachers' organizations have all made efforts to improve the teaching of mathematics over the years. There have been numerous research studies that have sought to identify the various factors affecting mathematics learning and teaching which address the issue of low scores of students in (Anaduaka, 2013; Clement 2013; Joseph 2020). These are areas where teachers are brought together to be exposed to innovative instructional strategies and resources that can be used to make mathematics learning and teaching meaningful.

In an effort to offer a long-term solution to the issue of poor accomplishment in mathematics, which includes algebra, academic achievement of children has become a key concern of policy makers, think tanks, mathematics instructors, and other stakeholders (Azuka, 2013). Due to this, the learning and teaching of mathematics have gained significant attention, necessitating immediate action. (Anaduaka, 2013) According to Obado (2007), In Nigeria, the focus of Mathematics instruction is on the teacher, where students are not seriously involved in the process. This could be the cause of low achievement in algebra. This study sought to find whether adopting the problem-based learning (PBL) technique will improve students' performance and retention in algebra as part of the effort to find a means to involve students more in learning and teaching process.

In order to aid medical students' learning, problem-based learning (PBL) was first implemented at McMaster University in Canada in the 1960s. The method pulls problematic real-world tasks to support students appreciate principles and concepts as opposed to the direct facts and content exhibitions. Haslett (2011) describes PBL as a learner-centered environment where students produce their own knowledge and work together to find answers to the issues that motivate learning. In PBL, students participate in collaborative activities to solve problems, and the instructor only serves as a facilitator rather than a primary source of information or a knowledge distributor. This acknowledges the students' efforts, ideas, and prior knowledge. Teachers in problem-based learning environments include students in the learning and teaching process as well as apply what they have learned in practical contexts. This goes beyond simply imparting mathematical knowledge to the students.

The problem-based learning approach fosters the development of problem-solving, learning abilities and critical thinking. People try to discover specific solutions to the problems they encounter in their daily lives, which might include a variety of issues. According to (Cindy & Eberbach, 2015), PBL seeks to assist students develop self-directed learning skills, flexible knowledge, effective problem-solving abilities, intrinsic motivation, and successful collaboration skills. In problem-based learning, students are given the task of applying a problem-solving strategy to problems they may not have previously faced or resolved. Since the instructor may have already run into the issue, the problem is not always brand-new; rather, they could be helpful older issues. A student or group of students working together to solve an issue must critically use the knowledge they have all learned to create a solution, searching out and creating new knowledge when necessary. Working together to solve the problem helps students develop abilities like creativity, critical thinking, cooperation, and a range of communication skills, all of which are crucial for success in school and in life.

In the sphere of education, gender disparity has been a topic of discussion for some time now. Male school participation rates in mathematics and science are greater than those of girls at the primary and secondary levels as a result of men's perceived superiority in those topics among pupils (Atovigba et al, 2012). Gender is a psychological word used to describe behaviour and characteristics expected of people based on whether they were born male or female, according to the (American Psychological

Association, 2015). The learning process of PBL in the classroom promotes collaboration and equal active participation between female and male students, which the researchers believe may improve both female and male students academic success in understanding algebras.

Statement of the Problem

Algebra is a branch of mathematics, and its teaching and learning are more procedural and involve drill and practice. Students struggle to understand mathematics in school, which has led to their subpar performance in the subject. This resulted in students being passive as teachers served as information providers because the proper teaching techniques were not being used. Therefore, pupils are not mastering the use of mathematics in daily life or the manipulation of symbols. Under this assumption, can Problem Based Learning approach enhance students' academic performance in algebra?

Purpose of Study

Investigating the effects of the Problem-Based Learning (PBL) method on students' algebra performance is major objective of the study. The research intends to:

1. determine the mean achievement scores of students taught algebra using Problem-Based Learning approach and those taught using expository method.
2. determine the difference between the mean achievement scores of female and male algebra students taught Problem-Based Learning method.
3. determine the interaction effects of methods and gender on students' achievement in algebra.

Research Questions

The stated research questions serve as the study's focal points:

1. What is the mean achievement scores of students taught algebra using Problem-Based Learning approach and those taught using expository method?
2. What is the mean achievement scores of female and male algebra students taught Problem-Based Learning method?
3. What is the interaction effects of methods and gender on students' achievement in algebra?

Hypotheses

The following hypotheses were examined in the study:

1. The mean achievement scores of students taught algebra using PBL approach and those taught using expository method did not differ significantly.
2. The mean achievement scores of female and male students who were taught algebra utilizing the problem-based learning method did not differ significantly.
3. Methods and gender do not significantly on students' achievement in algebra.

Research Methods

Quasi-experimental design using the non-randomized pre-test and post-test group design was used for the study because the entire classes were utilized. 3,173 Junior Secondary One (JSS 1) secondary school students from the Uyo Local Government Area were the study's population for the academic year 2018/2019. 124 JSS1 students consisted of the study's sample from two public secondary schools used for the study. The two schools were randomly drawn from 14 schools in the Uyo Local Government Area. The selection process was done using Simple random sampling technique. The Mathematics Achievement Test (MAT), a 40-item multiple-choice questionnaire constructed by the researchers with four lettered option choices, was used to collect data. There were two sections on Mathematics Achievement Test (MAT). Section A covered demographic data and Section B contained 40 multiple-choice questions with four options. All test questions were based on the idea of a linear algebraic expression involving addition, subtraction, multiplication, and division.

The researchers visited the chosen schools, taught the research assistants on how to utilize the problem-based learning pack for two days, and in the first week of the study, gave the two groups they had chosen a pretest on the Mathematics Achievement Test (MAT). Since the teacher was accustomed to using the expository technique, the research assistants in the control group received no training. Over the course of the following two weeks, the research assistants under the direction of the researchers taught algebra to the control and experimental groups. PBL was used to teach the experimental group; the expository method was used with the control group.

The experimental group received training through exposure to a real-world problem situation that demonstrated the use of the linear algebra concept. For instance, where a meeting was taking place, a

woman was selling fruits. She had ten oranges and fifteen mangoes. Where she was selling the fruits saw a stampede. She was able to retrieve three oranges and seven mangoes as the chaos subsided. How many oranges and mangoes went missing? The research assistants in an examination setting gave both the control and experimental groups a post-test on the Mathematics Achievement Test (MAT) at the conclusion of the two-week instruction. Following that, the scripts from the students in both groups

were gathered for scoring, score collation, and data analysis. Mean gain and standard deviation were utilized to answer research questions, and Analysis of Covariance (ANCOVA) was employed to evaluate the hypotheses. The significance level for testing the hypotheses was set at 0.05.

Results

Based on the study questions and hypotheses, the results are shown in tables and figures.

Table 1: The mean and standard deviation of the posttest scores for students who were taught using the PBL and expository method, using the pretest as a covariate.

Method	N	Pretest \bar{X}	SD	Posttest \bar{X}	SD	Mean Gain
Problem-based learning	65	10.69	2.07	27.54	4.30	16.85
Expository	59	10.75	2.51	24.78	4.35	14.03

According to Table.1, the mean pretest and posttest scores of students who received problem-based learning in algebra instruction were 10.69 and 27.54 respectively, whereas those who received expository algebra instruction were 10.75 and 24.78. The usage of the problem-based learning method was more successful than the expository method, as seen by the students' respective mean gain scores of 16.85 and 14.03 when they were taught algebra, respectively.

Table 2: Mean and Standard Deviation of Posttest Scores for Male and Female PBL Students with Pretest as Covariate

Gender	N	Pretest \bar{X}	SD	Posttest \bar{X}	SD	Mean Gain
Male	28	10.46	1.69	28.29	4.44	17.83
Female	37	10.86	2.32	26.97	4.16	16.11

According to Table 2, the mean achievement scores for male students who were taught algebra using problem-based learning at the pre- and post-test were 10.46 and 28.29, respectively, while those for their female counterparts were 10.86 and 26.97. The fact that both male and female students' mean scores increased from the pretest to the posttest indicates that the strategy was successful in transferring the concept to both sexes. When male and female

students were taught algebra utilizing problem-based learning, the mean gain scores were 17,83 and 16,11, respectively. This comparison shows that male students had a greater mean gain score than their female counterparts.

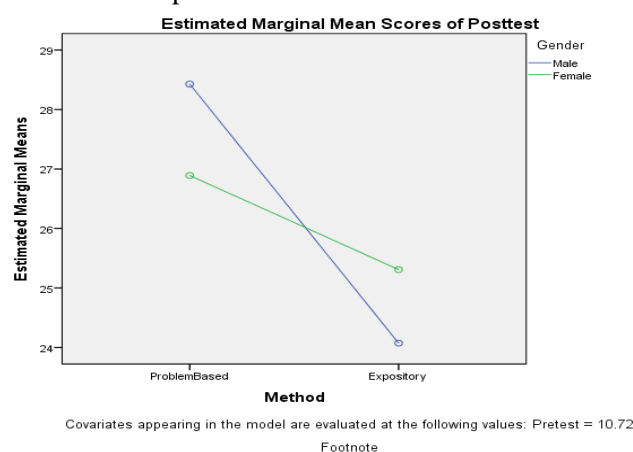


Fig. 1

The crossing lines are depicted in Figure 1. Given the cross-over interaction, it may be assumed that there is an interaction. When the hypothesis is tested, it will be confirmed how significant the interaction between the means of the male and female students is in terms of the two techniques.

Table 3: Analysis of Covariance of Student Posttest Scores Using Pretest as Covariate Based on Method.

Source of Variation	SS	Df	MS	F _{cal}	P-value _{cal}
Pretest	176.54	1	176.54	10.19	0.00*
Method	240.24	1	240.24	13.86	0.00*
Residual	2096.90	121	17.33		
Total	2513.68	123	20.44		

The calculated P-value for the procedure (0.00) is less than the significance level (0.05), as shown in Table 3. The null hypothesis is therefore rejected. This suggests that the mean achievement scores of

students taught algebra using problem-based learning and those taught using expository method differ significantly from one another.

Table 4: Analysis of Student Posttest Covariance Using Pretest as Covariate for Male and Female Students.

Source of Variation	SS	Df	MS	F _{cal}	P-value _{cal}
Pretest	48.94	1	48.94	2.76	0.10
Gender	35.34	1	35.34	2.00	0.16
Residual	1097.87	62	17.71		
Total	1182.15	64	18.47		

Table 4 revealed that the gender P-value at 0.16 is greater than the significance level (0.05). The null hypothesis is therefore not rejected. This connotes that there is no significant difference in the mean achievement

levels of male and female algebra students who received PBL instruction.

Table 5: Analysis of Covariance of Methods and Gender Interaction Effects on Achievement.

Source of Variation	SS	Df	MS	F _{cal}	P-value _{cal}
Pretest	176.54	1	176.54	10.31	0.00
Methods	240.24	1	240.24	14.03	0.00
Gender	1.40	1	1.40	0.08	0.78
Strategies*Gender	58.00	1	58.00	3.39	0.07
Residual	2037.50	119	17.12		
Total	2513.68	123	20.44		

The computed P-value (0.07) of Methods * gender is higher than the alpha threshold (0.05), as seen in Table 5. The null hypothesis is therefore not rejected. Thus, the effect of methods and gender on each other is the same at all levels of the other factor (achievement), indicating that there is no substantial interaction effect of gender and method on students' algebra achievement.

Discussion of Findings

The results showed a reasonable difference between the mean achievement scores of students taught algebra utilizing PBL and expository techniques. PBL-taught students performed better academically than expository-taught students. The results may be ascribed to PBL's ability to help students improve their ability to solve problems, think critically, and learn. It may be for this reason that Hmelo-Silver and Eberbach (2015) believed that problem-based learning promotes the development of flexible knowledge, effective problem-solving skills, effective self-directed learning skills, effective collaboration skills, and intrinsic motivation in students. The study's findings are consistent with those of Inel and Balim (2010), who discovered a significant difference in favour of the problem-based learning method on students' scores on the academic achievement test.

The results on the mean achievement score difference between male and female mathematics students who were taught algebra using problem-based learning indicated a non-significant difference. The results could be attributed to problem-based learning because it stimulates both male and female students' intellectual thinking through the same problems that are presented to them. Both male and female students may have exchanged ideas as a result of the strategy, thus raising both groups' academic performance. The study's conclusion is consistent with that of Orji and Ogbuanya (2018), who discovered that there was no discernible gender difference in students' academic achievement. The study's findings are consistent with those of Adu and Olaoeye (2015), who found no significant main effect of gender on students' academic achievement, whether they were male or female.

The results of the method and gender interaction on students' achievement in algebra revealed a non-significant interaction. This shows that at all levels of accomplishment, the impact of methods and gender are the same. The study's findings concur with those of Umoke and Nwafor (2014), who discovered no statistically significant interaction between method and gender on students' mean academic performance. The study's findings conforms with those of Abonyi, Maduagwuna, and

Ugama (2014), who discovered no discernible interaction between methods and gender on students' achievement in basic science.

Conclusion

Problem-based learning should be taken into account when teaching linear algebra. By encouraging students to think critically, be adaptable, develop effective problem-solving skills, self-directed learning skills, effective collaboration skills, and intrinsic motivation, the method will improve students' academic performance. It will also help students realize that the purpose of teaching mathematics is to help them solve real-world problems rather than for its own sake.

Recommendations

The following suggestions were made in light of the findings and judgments reached:

1. Mathematical educators should embrace and employ the Problem-Based Learning (PBL) method while instructing students on the principles of linear algebra.
2. PBL should be included in the mathematics curriculum, according to educational policy makers including the National Education Research Development Council (NERDC), curriculum planners, and the Ministry of Education.
3. The use of PBL in the classroom for mathematics instructors should be promoted by mathematical associations like the Mathematical Association of Nigeria (MAN) and the Science instructors' Association of Nigeria (STAN).

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