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EFFECT OF PROBLEM-BASED LEARNING METHOD ON PUPILS' ACHIEVEMENT AND RETENTION IN MATHEMATICS IN ORUMBA SOUTH LOCAL GOVERNMENT EDUCATION AUTHORITY, ANAMBRA STATE

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ABSTRACT

This study investigated the effect of Problem-Based Learning Method (PBLM) on pupils' academic achievement and retention in Mathematics in Orumba South Local Government Education Authority. Four research questions guided the study and six hypotheses were tested at 0.5 level of significance. The study adopted a quasi-experimental research design. The population of the study comprised 973 basic 5 pupils in the 43 public primary schools in the study area. 64 pupils formed the sample size which was selected using multi stage sampling procedure. The instrument for data collection was Pupils Everyday Statistics Achievement Test (PESAT). The instrument was validated by three experts. The reliability coefficient of 0.72 was established for PESAT using Kudar Richardson's formula 20 (KR-20).Mean and standard deviation were used to answer the research questions. Analysis of Covariance (ANCOVA) was used to test the null hypotheses. The findings of the study revealed that Problem-Based Learning Method (PBLM) is more effective in enhancing pupils' achievement and retention in Mathematics than the conventional expository method. There was no significant difference in the achievement and retention in mathematics due to gender. Also, there was interaction effect of teaching methods and gender on pupils' achievement and retention in mathematics. Based on the findings, it was recommended among others that PBLM be adopted by mathematics teachers to optimize learning outcomes for all pupils.

Keywords: Achievement, Mathematics, Problem-Based Learning Method, Retention**,**

Introduction

Mathematics is a core and compulsory subject at the basic education level. It is taught daily or at least four times in a week. According to Okigbo & Anyanwumelu (2021) Mathematics is the study of relationship which revolves around the elementary practice of writing, measuring and describing of shapes and objects. Joshua cited in Njoku & Okigbo, (2020) describes mathematics as a discipline that trains the human mind to understand the world by symbolically and systematically performing reasoning and computation on abstract structures. In the context of this study, Mathematics is viewed as a subject that equips the child with skills of numeracy, problem solving and critical thinking.

Today, more than ever before, all fields of knowledge are dependent on Mathematics for solving problems, stating theories and predicting outcomes. According to Nwankwo & Nwankwo (2020) any laudable achievement in technological development will be hampered if the potential scientists, engineers and technologists are not equipped with sound knowledge of Mathematics. Nwankwo & Nwankwo (2020) maintained that Mathematics is no longer the prerogative of only scientists, engineers and technologists; it is increasingly being used for analysis within the society as a whole. Mathematics is the mother or queen of all sciences; without doubt it remains the most serviceable subject to all disciplines and fields of human endeavor. Mathematics taught from Basic one to nine lays a solid foundation for senior secondary Mathematics which eventually paves way for the final Senior School Certificate Examination (SSCE).

The Mathematics curriculum broad themes represented include Number and Numeration, Basic Operations, Measurement, Practical and Descriptive Geometry, Everyday Statistics and Elements of Computer Operations. This researcher is interested in one of the broad themes of Mathematics; Everyday Statistics. Everyday statistics as a broad theme in mathematics has a practical value in academics as well as other areas of life. The study of statistics spirals up to the upper basic education classes through the senior secondary school. Everyday statistics at the basic education level include topics such as mean,

median, mode, tossing of coins, tally marks, bar and pie chart among others (NERDC, 2012). This perceived difficulty can lead to aversion for the subject as can be seen from the primary up to the secondary, undergraduate and post graduate levels in the university. This aversion may later translate to poor achievement in the subject across all levels. In support of this assertion, Ajai & Imoko (2015) noted that it is unfortunate to observe however, that many primary school pupils dread Mathematics and would do anything to avoid it. This poor achievement can be seen in the Basic Education Certificate Examination scores in Mathematics for the 2021, 2022 and 2023 academic sessions. Poor achievement in a subject can be attributed to poor teaching methods. Conventional teaching methods such as the Lecture, Direct and Expository method among others encourage rote memorization of facts. This method of teaching therefore might not be capable of effecting meaningful learning especially in mathematics. Many studies (Okeke, 2013; Okigbo & Ezeanyi, 2020; Ahmed & Okigbo, 2021) had revealed that achievement of students could be influenced by methods, instructional strategies and techniques adopted in teaching such subjects. Therefore, using an alternative teaching method cannot be over-emphasized in redressing this situation and enabling pupils to perform better in Mathematics. It is therefore more pertinent that a method which would improve pupils' achievement and retention be used.

Teaching methods can influence how learners learn and retain concepts they have been taught. Teaching methods refer to the process of transmitting facts, skills, information and knowledge by the teacher, so as to engage pupils in meaningful activities for learning and to achieve the objectives of the lesson. Fatade, Mogari & Arigbabu (2013) noted that effective teaching and learning of Mathematics could only be achieved through introduction of various innovative methods that are cognitively learner-centered, minds-on, hands-on, and peer-mediated like Problem-Based Learning Method (PBLM). Navy & Kaya, (2020) recognized that Problem Based Learning method emphasizes mathematical problems based on real life

situations and helps pupils to make connections with the real world and also realize that what they learn in the classroom can be used in their daily lives. Mathematics topics are interwoven. For example, knowledge about a procedure for adding common fraction may be needed when it comes to the addition of rational fractions**.** Problem-based learning as a focused, experiential learning, organized around the investigation and resolution of real world problems is a method consistent with the method of teaching that was envisioned by the FRN (2013) as participatory, exploratory, experimental and child-centered and may improve achievement and retention in Mathematics.

Academic achievement is the learning outcome which indicates the level of mastery, proficiency and knowledge shown by an individual after learning has taken place. According to Ikwuka & Samuel (2017), academic achievement is the outcome of education which indicate the extent to which a student, teacher or institution has achieved their educational goals and this is commonly measured by examinations or continuous assessment. Academic achievement, in the context of this study therefore, is a measure of the degree to which the pupil has gained mastery of the objectives as proposed in a Mathematics lesson. Mathematics learning can be enhanced when learners are able to retain contents taught them. Retention is an important aspect of learning. Katchy (2021) defined retention as the capacity to remember skills and knowledge initially acquired. Retention is the ability of a learner to remember mathematical formula, skills, knowledge or other responses initially taught and use them when needed. Gender is an important variable that could influence achievement in different subject areas. Gender is a term which describes behavior and attributes expected of individuals on the basis of being either male or female in a given society (Oludipe, 2012). Onuh & Okigbo, (2020) refers to it as the roles and responsibilities of men and women that are created in families, societies and culture. It seems that the influence of gender on achievement and retention has remained inconclusive. For instance, Abubakar & Adegboyega (2012) reported that gender was insignificant in the academic achievement of pupils in Mathematics. Also,

Adesina et al., (2015), reported that there is no significant difference between mathematical skills acquisition and gender. On the contrary, (Okigbo & Anyanwumelu, 2021; Efa & Frimpong, 2023) revealed that gender was significant in the achievement of students based on the instructional approach. From the foregoing, it becomes clear that inconclusive reports exist on influence of gender on achievement in mathematics when taught using different instructional methods. From observation, little attention is paid to the theme of everyday statistics; also the conventional (expository) method is frequently used in mathematics instruction in basic education level. The researchers are worried that if the method of teaching and learning of mathematics remains as it is presently, pupils in Anambra State basic education system may continually lag behind, hence, the need for an innovative and practical method such as the Problem Based Learning method. This kind of situation therefore calls for further study on academic achievements and retention of male and female pupils in Mathematics. Therefore the study investigated the effect of problem based learning method on pupils' academic achievement and retention in Mathematics as well as the influence of gender on these effects.

Research Questions

The following research questions guided the study:

- What is the difference between the mean achievement scores of pupils taught Mathematics using problem-based learning method and those taught using conventional method?
- What is the difference between the mean retention scores of pupils taught Mathematics using Problem-Based Learning Method and those taught using conventional method?
- What is the difference between the mean achievement scores of male and female pupils taught Mathematics using Problem-Based Learning Method?
- What is the difference between the mean retention scores of male and female pupils taught Mathematics using Problem-Based Learning Method?

Hypotheses

The following null hypotheses were tested;

- There is no significant difference between the mean achievement scores of pupils taught Mathematics using Problem-Based Learning Method and those taught with conventional method.
- There is no significant difference between the mean retention scores of pupils taught Mathematics using problem-based learning method and those taught with conventional method.
- There is no significant difference between the mean achievement scores of male and female pupils taught Mathematics using Problem-Based Learning Method.
- There is no significant difference between the mean retention scores of male and female pupils taught Mathematics using Problem-Based Learning Method.
- There is no interaction effect of teaching methods and gender on pupils' academic achievement in Mathematics.
- There is no interaction effect of teaching methods and gender on pupils' retention in Mathematics.

Methods

Study Design

The study adopted a quasi-experimental research design to investigate the effect of Problem-Based Learning Method (PBLM) on pupils' academic achievement and retention in Mathematics in Orumba South local government education authority. Four research questions guided the study and six hypotheses were tested at 0.05 level of significance. Though a rural area, Orumba South L.G.A. is at the verge of urbanization with its increased opportunities for education. Specifically, the pretest, post-test, non-randomized experimental groups was used.

Population of the Study

The population of the study comprised 973 basic 5 pupils in the 43 public primary schools in the study area. Each of the 43 public primary schools in Orumba South Local Government Education Authority has one stream of basic five classes. From these 43 schools, multi stage sampling procedure was used to select two (2) schools. From these two schools, two intact classes comprising 34 male and 30 female pupils (64) formed the sample size which was selected.

Instrument for Data Collection

The instrument for data collection was Pupils Everyday Statistics Achievement Test (PESAT). PESAT consisted 40-item multiple choice questions with four options A-D adapted from the Mathematics Association of Nigeria basic 5 textbook based on lessons that were taught. A table of specifications (Test-blue print) was used to draw up the 40-item PESAT. This is to ensure content validity of the test items. Instructional packages used for treatment during the problem-based method and the expository treatments were designed by the researcher.

Validation and Reliability of Instrument

The PESAT was validated by three experts, one from the Department of Early Childhood and Primary Education, one from the Department of Science Education, both from Nnamdi Azikiwe University, Awka and an expert in Measurement and Evaluation, from the School of Education (Degree program), Federal College of Education, (Technical), Umunze. The reliability coefficient of internal consistency obtained was 0.72 established for PESAT using Kudar Richardson's formula 20 (KR-20).

Experimental Procedures

The experimental aspect of the study was conducted in four stages. The first stage was briefing and familiarization of the research assistants who were the regular Mathematics teachers of the two selected primary schools. These teachers of the selected schools were used to avoid faking of behaviors on the part of the pupils. The regular mathematics teachers were given one (1) week briefing by the researcher to ensure effectiveness of instructional delivery for a better experimental outcome. The second stage was pre-testing when both groups (Experimental and Control) were given pretest before the commencement of the experiment. The third stage was teaching of pupils by the regular Mathematics teachers.

The Mathematics teachers taught the experimental group four (4) lesson (each a week) using the problem based learning method lesson plan on Everyday Statistics. On the other hand, the control group was taught the same four (4) lessons (each a week) using conventional method lesson plans on Everyday Statistics. After teaching the pupils for four (4) weeks, the final stage (stage 4) was post-testing and retention test. Here, both the experimental and control groups were given post-test and after two weeks they were given retention test using PESAT. The scores of the experimental and control groups in both the pretest, post-test and retention tests were recorded.

Method of Data Analysis

Research questions were answered using mean and standard deviation. The analysis of covariance was used to test the null hypotheses at 0.05 level of significance. Decision rule for the hypothesis is that null hypothesis is rejected when the probability value is less than or equal to the significant value of 0.05 ($p \leq 0.05$) otherwise the hypothesis is accepted.

Results

The results are presented in tables according to the research questions and hypotheses

Table 1: Difference between the mean achievement scores of pupils taught Mathematics using problem-based learning method and those taught using conventional method

Groups	N	Mean	Std. Deviation	Mean Diff	Decision
Scores of Pupils (PBLM)	27	23.19	4.27	15.03	PBLM>Expo
Scores of Pupils (Expo)	37	8.16	2.80		

Table 1 shows the difference between the mean achievement scores of pupils taught Mathematics using problem-based learning method and those taught using conventional method. Pupils taught with PBLM have mean achievement score of 23.19 and SD of 4.27 while pupils taught with conventional method had mean achievement score of 8.16 and SD of 2.80. This leaves a mean difference of 15.03 in favor of pupils taught with PBLM.

Table 2: Difference between the mean retention scores of pupils taught Mathematics using problem-based learning method and those taught using conventional method

	N	Mean	Std. Deviation	Mean Diff	Decision
Mean retention scores of pupils in PBLM	27	29.44	5.65	15.39	PBLM>Expo
Mean retention scores of pupils in Expo.	37	14.05	6.01		

Table 2 shows the difference between the mean retention scores of pupils taught Mathematics using problem-based learning method and those taught using conventional method. Pupils taught with PBLM have mean retention score of 29.44 and SD of 5.65 while pupils taught with expository method have mean retention score of 14.05 and SD of 6.01. This leaves a mean difference of 15.39 in favor of pupils taught with PBLM.

Table 3: Difference between the mean achievement scores of male and female pupils taught Mathematics using problem-based learning method

	N	Mean	Std. Deviation	Mean Diff	
Scores of Male Pupils in PBLM	13	22.62	5.19	1.09	Female>Male
Scores of Female Pupils in PBLM	14	23.71	3.31		

Table 3 shows the difference between the mean achievement scores of male and female pupils taught Mathematics using problem-based learning method and those taught using conventional method. Male and female pupils taught with PBLM have mean achievement score of 22.62 and 23.71 respectively, and SD of 5.19 and 3.31 respectively. This leaves a mean difference of 1.09 in favor of female pupils.

Table 4: Difference between the mean retention scores of male and female pupils taught Mathematics using problem-based learning method

	N	Mean	Std. Deviation	Mean Diff.	Decision
Scores of Male Pupils	13	24.62	3.31	9.31	Female>Male
Scores of Female Pupils	14	33.93	2.97		

Table 4 shows the difference between the mean retention scores of male and female pupils taught Mathematics using problem-based learning method. Male pupils taught with PBLM have mean retention score of 24.62 and SD of 3.31 while female pupils taught with PBLM have mean retention score of 33.93 and SD of 2.97. This leaves a mean difference of 9.31 in favor of female pupils.

Table 5: Analysis of Covariance (ANCOVA) on significant difference between the mean achievement scores of pupils taught Mathematics using Problem-Based Learning Method and those taught with conventional method

Tests of Between-Subjects Effects

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Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14.221[a]	13	1.094	79.955	.000	.958
Intercept	42.805	1	42.805	3128.730	.000	.986
Pretest	.037	1	.037	2.728	.105	.056
Scores	11.049	12	.921	67.301	.000	.946
Error	.629	46	.014			
Total	405.000	60				
Corrected Total	14.850	59				

a. R Squared = .958 (Adjusted R Squared = .946)

Table 5 shows the ANCOVA test of significant difference between the mean achievement scores of pupils taught Mathematics using PBLM and those taught with conventional method. The p-value of .00 is less than the alpha value of 0.05. This indicates that the difference in mean scores is significant. The null hypothesis therefore is not accepted. There is significant difference between the mean achievement scores of pupils taught Mathematics using PBLM and those taught with conventional method.

Table 6: Analysis of Covariance (ANCOVA) on significant difference between the mean retention scores of pupils taught Mathematics using Problem-Based Learning Method and those taught with conventional method

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	12.603[a]	18	.700	10.479	.000	.807
Intercept	46.298	1	46.298	692.923	.000	.939
Pretest	.208	1	.208	3.106	.085	.065
Scores	10.385	17	.611	9.143	.000	.775

Error	3.007	45	.067
Total	441.000	64	
Corrected Total	15.609	63	

a. R Squared = .807 (Adjusted R Squared = .730)

Table 6 shows the ANCOVA test of significant difference between the mean retention scores of pupils taught Mathematics using PBLM and those taught with conventional method. The p-value of .00 is less than the alpha value of 0.05. This indicates that the difference in mean scores is significant. The null hypothesis therefore is not accepted. There is significant difference between the mean retention scores of pupils taught Mathematics using PBLM and those taught with conventional method.

Table 7: Analysis of Covariance (ANCOVA) on significant difference between the mean achievement scores of male and female pupils taught Mathematics using Problem-Based Learning Method

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.220[a]	8	.277	1.105	.405	.329
Intercept	.446	1	.446	1.777	.199	.090
Pretest	.035	1	.035	.139	.714	.008
Scores (M/F)	2.036	7	.291	1.158	.373	.310
Error	4.521	18	.251			
Total	14.000	27				
Corrected Total	6.741	26				

a. R Squared = .329 (Adjusted R Squared = .031)

Table 7 shows the ANCOVA test of significant difference between the mean achievement scores of male and female pupils taught Mathematics using PBLM. The p-value of .373 is greater than the alpha value of 0.05. This indicates that the difference in mean scores is not significant. The null hypothesis therefore is accepted. There is no significant difference between the mean achievement scores of male and female pupils taught Mathematics using PBLM.

Table 8: Analysis of Covariance (ANCOVA) on significant difference between the mean retention scores of male and female pupils taught Mathematics using Problem-Based Learning Method

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6.741[a]	11	.613	151.000	.000	1.000
Intercept	.360	1	.360	887.000	.000	1.000
Pretest	.000	1	.000	.000	1.000	.000
Scores (M/F)	6.556	10	.656	161.000	.000	1.000
Error	6.077E-30	15	4.051E-31			
Total	14.000	27				
Corrected Total	6.741	26				

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

Table 8 shows the ANCOVA test of significant difference between the mean achievement scores of male and female pupils taught Mathematics using PBLM. The p-value of .00 is less than the alpha value of 0.05. This indicates that the difference in the mean retention scores is significant. The null hypothesis therefore is not accepted. There is significant difference between the mean retention scores of male and female pupils taught Mathematics using PBLM.

Table 9: Regression analysis on interaction effect of teaching methods and gender on pupils' academic achievement in Mathematics

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	46.476	1	46.476	108.636	.000[b]
	Residual	26.524	62	.428		
	Total	73.000	63			

a. Dependent Variable: Gender and method

b. Predictors: (Constant), Scores

Table 9 shows the regression analysis on interaction effect of teaching methods and gender on pupils' academic achievement in Mathematics. The p-value or significant value is .00 which is less than 0.05, indicating that the variation which occurred in the scores of pupils is due to method and gender. There is therefore interaction effect of teaching methods and gender on pupils' academic achievement in Mathematics.

Table 10: Regression analysis on interaction effect of teaching methods and gender on pupils' retention in Mathematics

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27.437	1	27.437	37.335	.000[b]
	Residual	45.563	62	.735		
	Total	73.000	63			

a. Dependent Variable: Gender and method

b. Predictors: (Constant), Scores

Table 10 shows the regression analysis on interaction effect of teaching methods and gender on pupils' retention in Mathematics. The p-value or significant value is .00 which is less than 0.05, indicating that the variation which occurred in the scores of pupils is due to method and gender. There is therefore interaction effect of teaching methods and gender on pupils' retention in Mathematics.

Discussions

The findings of the study showed that these is a significant difference between the mean achievement scores of basic education pupils taught Mathematics using Problem Based Learning Method and those taught using conventional expository method in favor of Problem Based Learning Method (PBLM) group. This finding aligns with the study of Nese & Nese (2014) indicating that PBLM leads to better academic outcomes in Mathematics. The basic education pupils in Problem Based Learning Method group performed better than those in conventional expository method (CEM) group because PBLM is a sort of

realistic method where the pupils were given opportunity to exercise their mastery over the content of the learning materials and to ensure they were able to make progress in each phase of learning based on the established knowledge they have in the previous phase. Problem Based Learning Method it is a pupil-centered instructional strategy that involves critical thinking in order to solve real life problems aimed at empowering learners to take responsibility for their learning. It also helps the pupils develop in them appropriate mastery skills that will enable them successfully move from one level of knowledge to the other in a given learning process thereby improving their achievement and retention in the subject matter. The findings of the study are consistent with the results of previous studies. For instance, Zakariya, Ibrahim & Adisa (2016) found that Problem-Based Learning Method (PBLM) enhances problem-solving skills and supports long-term retention of knowledge. The significant effect of the teaching method (PBLM) on achievement scores aligns with this study, indicating that PBLM leads to better academic outcomes in Mathematics. The findings of the study are also in line with Zakariya, Ibrahim & Adisa (2016) who found that PBL enhances knowledge retention as students are better able to apply and retain information over the long term. The finding showed that pupils taught with PBLM retained more information compared to those taught with the Conventional expository Method. Both groups show variability in retention scores, but the PBLM group has slightly less variability, suggesting more consistent retention among pupils.

Gender was also significant in the achievement of pupils based on the instructional approach. There was a significant difference in the achievement of male and female student who were taught mathematics using scaffolding instructional approach. The finding of the study is in line with that of Okigbo & Anyanwumelu (2021) whose study revealed that gender is a factor in learners' achievement in mathematics. The finding of the study is contrary to that of Ajai & Imoko (2015) & Adesina et al., (2015) whose studies revealed that gender is not a factor in pupils' achievement in mathematics when problem based learning method is

applied in teaching. The interaction effect of teaching approaches and gender was examined on achievement of the students in mathematics. It was observed that gender and treatment has significant interaction on students' achievement. This implies that male and female students react differently to the treatment in terms of their academic achievement in mathematics. This is in line with Efa & Frimpong (2023) who found that the interaction between teaching methods and student characteristics, such as gender, can significantly impact academic achievement. In other words, the teaching strategies used in the study imparted differently on male and female students based on their academic achievement in mathematics.

Conclusion

Based on the findings, it was concluded that the use of PBLM in teaching mathematics was more effective than the use of CEM. Moreover the use of PBLM favored females in learning of mathematics; the differential impact of PBLM on male and female pupils highlights the importance of considering gender when implementing teaching methods. Overall, the results obtained from this study comply with the general expectation of educators that innovative teaching methods which center on the children are more educationally rewarding than the conventional method which is teacher-centered.

Recommendations

From the findings of the study, it was recommended that:

- Curriculum planners should incorporate PBLM into the Mathematics curriculum to leverage its effectiveness in enhancing achievement and retention.
- Teachers should design and implement gender-sensitive teaching strategies within the PBLM framework to address the varying impacts on male and female pupils.

- The state government should offer professional development programs for teachers focused on the effective use of PBLM, including strategies for addressing gender differences and maximizing its benefits.
- Teachers should establish regular assessment and feedback mechanisms to evaluate the impact of PBLM on learners' achievement and retention.
- Teachers should promote collaborative learning and peer support within the PBLM framework to enhance engagement and facilitate knowledge sharing among pupils.

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