Effects of Mathematical Language on the Achievement of Junior Secondary School Students in Mathematics in Bauchi Metropolis, Bauchi State, Nigeria

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ABSTRACT

The study investigated the effect of mathematics language on the achievement of Junior secondary school students in mathematics. The study adopted quasi-experimental design, which involved non-equivalent pre-test and post-test design. It concerns the use of two intact classes, for experimental and control groups. The population of the study comprised of junior secondary school student in Bauchi Metropolis, Bauchi State Nigeria. There is eighty (80) Junior Schools in Bauchi Metropolis with a total of 14,828 students. A sample of 2 Junior Secondary Schools with a total of 118 students were used for the experimental and control group. two research questions were developed and two hypotheses were used for the study. A Stratified sampling technique and simple random sampling the participate in the study. two instruments were used for the study which is Mathematics Achievement Tests (MAT) and Mathematics Sign and Symbols questionnaire (MSSQ). Descriptive statistics (mean scores and standard deviation) were used to answer the research questions–. The hypotheses were tested using ANCOVA at the 0.05 level of significance through the Statistical package for social sciences (SPSS). It was discovered that students achieve better in mathematics if they are expose to mathematics language and it was also found that female students performed slightly better than their male counterparts in mathematics when taught using mathematics language.

Key words: Mathematics language, Mathematics Achievements, gender

INTRODUCTION

Mathematics is a foundational academic content area important for student success throughout school and is universally recognized as one of the core subjects that under pin scientific, technological, and economic development in every nation. In the field of human endeavor Mathematics cut across all science fields including medicine, biotechnology, anatomy, nursing, engineering, computer and has become the heart of many reputable careers and successful lives for societal development, (Aliyu, Waziri & Adamu, 2020). In Nigeria Mathematics has been made a compulsory subject at both the primary and secondary school levels because of its relevance in all field of study. Despite its importance, students' achievement in Mathematics at the junior secondary school level has remained unsatisfactory over the years, especially in concepts that require logical reasoning, interpretation of symbols, and understanding of mathematical expressions. Researchers have linked this low and inconsistent performance to several factors, among which mathematical language has received increasing scholarly attention. (Yakusak & Yusuf, 2022; Ajai, Iyekekpoor & Hanawa, 2020)

Mathematical language refers to the specialized vocabulary, symbols, expressions, signs, and communication patterns used in the teaching and learning of Mathematics. It includes mathematical terminologies, operational

symbols, graphs, equations, and sentence structures that enable learners to understand and communicate mathematical ideas effectively. To attain proficiency in mathematics, students must be able to understand and use mathematical language, (Himmelsbach Hill, Liu & Demszky. 2023) Unlike everyday language, mathematical language is precise, symbolic, and abstract, making it difficult for many students to comprehend. When students fail to understand the language through which mathematical ideas are communicated, their achievement in the subject may be marred by misunderstanding and misinterpretation. This is because understanding mathematical concepts depends largely on the learner's ability to interpret mathematical terms, instructions, and symbols correctly, (Oguguo. 2020)

In recent years, scholars such as Oguguo, (2020); Badru, Adewale, Owodunni, (2021); and Oguguo & Eluozo, (2023) have emphasized that mathematical language plays a critical role in students' academic achievement in Mathematics. Studies have shown that learners who possess adequate understanding of mathematical vocabulary and symbols tend to perform better in problem-solving and abstract reasoning than those with poor mathematical language skills. For instance, a study on the effect of language of instruction on students' performance in Mathematics revealed that students taught with familiar and comprehensible mathematical expressions achieved significantly better than those exposed only to conventional instructional language. Similarly, research on students' understanding of mathematical language established a significant relationship between mathematical language comprehension and achievement in Mathematics. (Luka, 2024 and Oguguo, 2020)

The issue becomes more critical at the junior secondary school level because this stage forms the foundation for higher mathematical learning. At this level, students are introduced to abstract concepts such as algebraic expressions, directed numbers, equations, and word problems, all of which require proper understanding of mathematical language. Many junior secondary school students experience difficulties in interpreting mathematical symbols, translating word problems into mathematical statements, and understanding teachers' explanations due to weak language competence in Mathematics. Consequently, students develop cool feet toward the subject, which may eventually affect their achievement and participation in Mathematics-related careers. (Akinoso, Olaniyi & Akinoso. 2025)

In Bauchi metropolis, concerns have continued to grow among educators, parents, and examination bodies regarding students' under-achievement in Mathematics at the junior secondary school level. Observations from classroom interactions suggest that many students encounter difficulties in interpreting mathematical instructions and solving problems expressed in symbolic or verbal forms. These challenges may be connected to inadequate exposure to mathematical language during classroom instruction. In many schools, Mathematics teachers often emphasize computation without paying adequate attention to the language structure of Mathematics. As a result, students may memorize procedures without understanding the meanings of mathematical concepts and terminologies.

Furthermore, the multilingual nature of the Nigerian educational environment may also contribute to students' difficulties in understanding mathematical language. Most junior secondary school students communicate mainly in indigenous languages outside the classroom, while Mathematics instruction is delivered in English language combined with specialized mathematical symbols and vocabularies. This creates a language gap that may hinder effective comprehension of mathematical concepts. Studies conducted in northern Nigeria have shown that integrating familiar language expressions alongside English language instruction could improve students' understanding and achievement in Mathematics. (Ajai, Iyekekpolor, & Hanawa. 2022 and Phaladi, Rankhumise & Mwakapenda. 2024)

Another important variable associated with students' achievement in Mathematics is gender. Gender has remained a major issue in Mathematics education research because male and female students may differ in learning experiences, confidence, classroom participation, and achievement outcomes. While some studies reported significant gender differences in Mathematics achievement in favour of male students, others found no significant difference between male and female students when exposed to appropriate instructional strategies and supportive learning environment, (Iji & Abah 2017). In relation to mathematical language, gender may moderate how students interpret mathematical symbols, vocabulary, and problem-solving instructions. For example, differences in classroom interaction patterns, communication confidence, and exposure to

mathematical discourse may influence how male and female students benefit from mathematical language instruction.

Recent studies on Mathematics achievement in Nigeria have also incorporated gender as a moderating variable in determining students' academic performance. Findings from such studies indicated that effective instructional approaches can reduce gender disparities and improve achievement among both male and female students, (Audu, Gimba & Abdulrahman, 2026). This suggests that when students are taught using comprehensible mathematical language and learner-friendly communication strategies, both genders may achieve better learning outcomes.

Moreover, researches Ozofor & Onas. (2018), revealed that female students fear mathematics more than male students, to the extent that, it is believed that mathematics is masculine and therefore should be a male dominating subject, this goes with the general believe that boys are more superior to girls in terms of physique, cognition and logical reasoning and even superior in terms of academic achievement. this negative believe has limit the female gender when it comes to the study of mathematics and other science related courses but with the exception of few females that has excel in this field of study.

Although several studies have examined students' achievement in Mathematics using different instructional strategies, limited empirical studies have focused specifically on the effects of mathematical language on the achievement of junior secondary school students in Mathematics in Bauchi metropolis with gender serving as a moderating variable. Most previous studies concentrated on instructional methods, technology-based learning, or language of instruction without adequately examining how mathematical language itself influences students' achievement within the context of Bauchi State. This gap therefore necessitates the present study on the effects of mathematical language on the achievement of junior secondary school students in Mathematics in Bauchi metropolis, Bauchi State, Nigeria, while considering gender as a moderating variable

Theoretical Framework

This study is anchored on two major theories that explain how students learn mathematics and how language influences understanding. These theories are: Constructivist Learning Theory and Social Constructivist Theory. These theories provide a strong foundation for explaining the relationship between mathematical language and Students' achievement in Mathematics.

Constructivist Learning Theory is associated with Jean Piaget, who proposed that learners actively construct knowledge based on their experiences and prior understanding. According to this theory, learning is not a passive process but an active process in which learners build new knowledge by connecting it with existing knowledge structures. In the context of mathematics learning, constructivism emphasizes that students learn best when they are actively involved in exploring mathematical concepts, solving problems, and discovering relationships. Mathematics, in particular, requires learners to construct meaning from symbols, expressions, and equations. Students must interpret these symbols and relate them to real-life situations in order to develop a meaningful understanding.

Constructivist theory is relevant to this study because it highlights the importance of meaning-making in learning mathematics. Mathematical language serves as a tool that helps students construct meaning from abstract concepts. When teachers use clear and appropriate mathematical language, students are better able to understand and internalize mathematics concepts. Conversely, poor understanding of mathematical language can hinder the construction of knowledge, leading to misconceptions and poor achievement.

Language plays a central role in social constructivism because it is the primary means through which knowledge is communicated and shared. In mathematics classrooms, students learn by discussing ideas, explaining their reasoning, and engaging in collaborative problem-solving. Mathematical language, therefore, becomes a crucial tool for facilitating learning.

The relevance of social constructivist theory to this study lies in its emphasis on communication and interaction in learning mathematics. The use of appropriate mathematical language during instruction enables students to

participate in discussions, ask questions, and express their ideas. This interaction enhances their understanding of Mathematics and increases their commitment to learn. When students are actively engaged in meaningful communication, they are more likely to develop confidence and achieve better learning outcomes.

The aim of this study was to determine the effect of mathematics language on achievement of junior secondary students in Bauchi metropolis of Bauchi state. The specific objectives are:

1. Find out the achievement of students taught mathematics using mathematics language and those taught without using Mathematics Language.
2. Find out the achievement of students taught mathematics using mathematical language based on gender.

Research Questions

The following research questions were formulated to guide the study:

1. What is the mean achievement score of students taught mathematics using mathematics language and those taught without using mathematics?
2. What is the mean achievement score of male and female students in mathematics in the experimental group in Junior Secondary Schools in Bauchi Metropolis?

Hypotheses

The following hypotheses are formulated to guide the study.

1. There is no significant difference in the mean achievement score of students taught mathematics using mathematics language and those taught without.
2. There is no significant difference in the mean achievement of male and female students in mathematics after being exposed to treatment.

METHODOLOGY

This study adopted quasi-experimental design, which involved non-equivalent pre-test and post-test design. It concerns the use of two intact classes, for experimental and control groups.

The population for this study comprised Public Junior Secondary Schools in Bauchi Metropolis. There is eighty (80) Junior Schools in Bauchi metropolis with a total of 14,828 students. A sample of 2 Junior Secondary Schools with a total of 118 students were drawn from the 80 school through purposeful and simple random sampling. One school was used as experimental group with 62 students and the other as control group with 56 students.

The instruments used for data collection are; Mathematics Achievement Tests (MAT) and Mathematical Signs and Symbol questionnaire (MSSQ). Mathematics achievement test was scrutinized and validated by experts in Mathematics and Research, Measurement and Evaluation (RME) units to ascertain its content and face validity after which, all necessary suggestions and corrections were made and its reliability was determined by the test–re-test method. The test was administered on two intact classes in Junior Secondary Schools outside the research sample but within the population. 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 Mathematics Achievement test. Similarly, the Mathematics Sign and Symbols questionnaire was taken to the same two junior secondary school for a pilot testing to ascertain its reliability, this was established using Cronbach alpha method of reliability. The reliability coefficient obtained was 0.92 which is reliable.

Descriptive statistics (mean scores and standard deviation) were used to answer the research questions while the hypotheses were tested using ANCOVA at the 0.05 level of significance through the Statistical package for social sciences (SPSS).

Administration of Pretest, treatment and posttest.

The pretest was administered on both the experimental and control groups. The students were given the Mathematical Sign and symbols questionnaire to fill-in by writing down the meaning of sign and symbols and the achievement test was also given to the two groups in order to determine their levels of achievement in Mathematics. The scores of each group were recorded and kept for future use.

Six weeks was used for the treatment on experimental group using mathematics language. Every mathematical term sign and symbols were define and explain in detail and are being differentiated from normal day to day usage. Four different periods of 40 minutes each week were use as contained in the school time table with the help a research assistant. The treatment was withheld from the control group. They were taught using the conventional method

At the end of the treatment, the posttest was conducted on the experimental and control groups in order to ascertain the effect of mathematics language on the students' achievement with the help of the research assistants. The posttest questions were the same with the pretest questions and the same Mathematics sign and symbols questionnaire was re-administered to the students to determine the effect of the treatment on the experimental group and the pretest and posttest were scored over 100, thereafter, the pretest and posttest mean scores were compared to find the differences in the students' achievement mean score of the experimental and control groups likewise the Mathematics Sign and Symbols questionnaire.

RESULTS

Research Question One

What is the mean achievement score of students taught mathematics using mathematics language and those taught without using mathematics language?

Table 1

Pretest and post-test Achievement of Mathematics Students in the Experimental and Control Groups

Group		Before		After			
	N	Mean	SD	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 shows the pre-test and post-test achievement mean score of students taught Mathematics using mathematics language and those taught without using mathematics language. From the result, in the experimental group the post-test mean score ($\bar{x}$ = 69.89, SD = 16.50) is higher than the pre-test mean score ($\bar{x}$=37.48SD =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 groups 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 mathematics language than those in the control group (39.41) who were not given treatment with a mean difference of 28.38.

This means that at the pre-test score for the students in both groups had a low performance, but after the intervention the experimental group performed better than the control group. It can be deduced that exposure to Mathematics language do improve students' achievement in Mathematics.

Research Question Two

What is the mean achievement score of male and female students in mathematics in the experimental group in Junior Secondary Schools in Bauchi Metropolis?

Table 2

Result of Post-test Achievement of Male and Female Students in Mathematics in the Experimental Group

Group	Gender	N	Pretest		Posttest			
			$\bar{x}$	SD	$\bar{x}$	SD	Mean Gain	$\bar{X}_{Diff}$
	Male	40	35.18	12.94	68.75	16.82	33.57	
Experimental								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 50.27 with a mean difference of 3.3. This implies that female students performed slightly better than their male counterparts in Mathematics when taught using Mathematics language.

Hypothesis One

There is no significant difference in the mean achievements score of students taught mathematics using mathematics language and those taught without.

Table 3

ANCOVA Result on Post-test Achievement Mean Scores 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	22.817	.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 Mathematics in experimental and control groups. Table 5 shows that F (1,115) = 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 mathematics language on students' achievement in Mathematics. The result further reveals an adjusted R squared value of .566 which means that 56.6 percent of the variation in the dependent variable which is achievement is explained by variation in the

treatment, while the remaining is due to other factors not included in this study. Hence, we can say that mathematics language can help improve students' achievement in Mathematics.

Hypothesis Two

There is no significant difference in the mean achievement score of male and female students in Mathematics after exposed to treatment.

Table 4

ANCOVA Result on Post-test Mean Achievement Scores of Experimental Group in Mathematics 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	100.25	.000	.630
Pre-test	110.990	1	110.990	.400	.529	.007
Gender	86.255	1	86.255	.311	.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 ($\overline{X}$ = 68.75; SD =16.82) and female ($\overline{X}$ = 71.95; SD = 16.09); F (1, 59) = .311, P > 0.05, partial η2 = .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 Mathematics do not significantly differ from those of female students. It means that students' achievement in Mathematics is not affected by gender.

DISCUSSION

From the research question one which states that what is the achievement of students taught mathematics using mathematics language and those taught without? The result from table 1. The findings show that students in the experimental group had a higher mean score after exposure to mathematics language than those in the control group who were not given treatment with a great mean difference. This means that at the pre-test the students in both groups had a poor performance, but after the intervention the experimental group performed better than the control group. It can be deduced that exposure to Mathematics language do improve students' achievement in Mathematics.

The result in table 2 shows the achievement of male and female students in mathematics 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 the male students. This implies that female students performed slightly better than their male counterparts in Mathematics when taught using Mathematics language.

Going by the analysis of covariance (ANCOVA) results on the effect of mathematical language on their achievement in mathematics as indicated in table three and four, the results proved that the first null hypothesis

is not retainable which means the first null hypothesis is rejected indicating that, there is a significant difference in the mean achievement score of students taught mathematics using mathematics language and those taught without using mathematics language.

On the other hand, the second null hypothesis is retained in other words, it is accepted, this implies that there is no significant difference in the mean achievement of male and female students in mathematics after exposed to treatment

From the findings of this study, it was discovered that students achieve better in mathematics if they are expose to mathematics language in Bauchi metropolis. Moreover, the finding also discover that female students performed slightly better than their male counterparts in mathematics when taught using mathematics language

CONCLUSION

From the findings of this study, it was discovered that students in Bauchi metropolis achieve better in mathematics if they are expose to mathematics language. Moreover, the finding also discovered that female students performed slightly better than their male counterparts in mathematics, when taught using mathematics language,

The study concluded that, teaching mathematics using mathematics language is one of the effective approaches of teaching the subject. Students achieve higher mean scores in mathematics when exposed to mathematics language

Recommendations

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

1. Employ well trained mathematics teachers that would teach Mathematics language effectively.
2. Mathematics teachers should be motivated and encouraged to attend seminars and workshops where new instructional strategies and approaches to teaching mathematics are promoted so as to advance beyond the traditional methods of instruction.
3. Bauchi State Government and stakeholders on education should Provide fully equipped mathematics laboratories in schools with relevant teaching materials that would help students to understand mathematics language correctly.
4. Teachers of Mathematics should ensure that Mathematical language required in any particular Mathematics topics are identified and taught prior to the application in the relevant lesson.

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