

EFFECTS OF FORMATIVE ASSESSMENT ON JUNIOR SECONDARY TWO STUDENTS' MATHEMATICS ACHIEVEMENT IN PLATEAU STATE

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Abstract

This study investigated the effects of formative assessment on junior secondary two students' Mathematics achievement in plateau state. This was motivated by poor performance of students in mathematics in internal and external examinations in Plateau State. The assessment of students' learning has been characterized by the use of summative assessment only by teachers and new ideas of improving performance through formative assessment is lacking in our schools. Four research questions and two hypotheses were answered and tested respectively. This study adopted a quasi-experimental design, specifically the non-randomised pretest posttest control group design. The population of the study was 2212 students and the sample consisted of 240 JS II students in four Government Junior Secondary Schools in Jos South and Barkin Ladi Local Government Areas. The sampling techniques employed were the stratified sampling and random sampling techniques. The instruments used for data collection were two equivalent form 1 and 11 essay tests adopted by the researcher from external examination questions from BECE mathematics. The instruments were validated to ensure that they had content validity using table of specification. The Kuder-Richardson method for reliability coefficient was used to estimate the internal consistency of the tests. The reliability result was .89 which was good. The method of data collection was testing. The data were analysed using frequency, percentages, mean, standard deviation ANCOVA and ANOVA. The results of this study reveals that the use of formative assessment improves students' understanding of the concepts taught and the strategies employed improved their Mathematics achievement. The implication is that teachers of mathematics should adopt the use of Formative Assessment for making the teaching and learning of mathematics more interesting and rewarding.

Keywords: Formative Assessment and Mathematics Achievement.

INTRODUCTION

Mathematics is the foundation of science and technology. The functional role of mathematics in science, technology and national development is so multifaceted that no nation can advance scientifically and technologically without mathematics. The Nigerian Federal Government made mathematics compulsory in the primary and secondary school levels of education (FRN, 2014). Despite the high position accorded to mathematics in the school curriculum, the strategies for assessing students' progress in junior secondary level of education have not yielded significant positive results (Okolo & Kolawole, 2018).

In spite of the vision and mission Plateau State Universal Basic Education Board (PSUBEB) has for every child residing in the state. To realize its vision and mission statement, the Board is expected to perform effective supervision and inspection of schools, training and retraining of teachers and execution of meaningful projects that will make education accessible and affordable to all school age children in Plateau State. In the year 2015 the United Nations adopted the 2030 Agenda for sustainable development that includes 17 Sustainable Developmental Goals (SDGs). The (SDGs) aim is to transform the world and Plateau State is within the world. They are a call to action to end poverty and inequality, protect the planet, and ensure that all people enjoy health, justice and prosperity. This is relevant to the teacher of mathematics to ensure that a good foundation is laid, as Mathematic is the key to science and Technology, Nation building and poverty eradication. In Nigeria, out of the 17 goals are adopting and making all necessary steps to accomplish 7 out of the 17 adopted in Nigeria. The 7 goals are Poverty, Health and well-being, Education, Gender equality, Inclusive economy, Enabling an environment of peace and security and Partnerships (Wikipedia). They are relevant to the teacher for the teaching, learning and assessment of students for a better understanding of Mathematics and proper placement of the students for the accomplishment of educational goals. They are relevant because they could help the state government to work toward meeting the vision and mission statement which concerns Education and Poverty eradication. This could enable Members of PSUBEB to ensure that teachers apply formative assessment strategies to improve mathematics and eradicate poverty. The Millennium Development Goals were set to be accomplished by the year 2015 but the visions failed to achieve their goals, this could be attributed to the fact that education and assessment were not properly supervised and utilised. These goals can be achieved if conceptualized framework for globalization is initiated from the classroom through proper teaching and assessment.

Despite the efforts made by various tenures of the Plateau State government to achieve the Educational goals, by organizing workshops for teachers, there is still persistently poor performance in Mathematics in the junior secondary school examinations conducted by Plateau State Basic Education Certificate Examination (BECE). The results revealed consistent poor performance such that the proportion of students who scored credit and above from 2021-2022 ranged from 30% to 41% in BECE mathematics according to the Examiners. Results look good when continuous

assessments are added and those that failed the examination are given opportunity to re-seat for better achievement. Consequent upon this is that most students cannot perform very simple mathematical operations needed for everyday life and work.

The areas the examiners of BECE observed the students found difficult to solve were questions related to word problems. Students misinterpreted the questions and answered them incorrectly as reported by the examiners. Word problems in mathematics are problems presented as texts rather than in mathematical notations. There are strategies for teaching and learning word problems for better understanding. One of these strategies is assessment for learning. This was applied in this study basically by focusing on the conceptual foundational knowledge, by visualizing complex problem and applying formative assessment in solving word problems using varieties of strategies depending on the questions presented. This enabled students also to apply critical thinking skills in solving them.

Factors that lead to students' poor performance have been identified by Japan International Corporative Agency (JICA) a study carried out in Plateau State in 2006 and still in practice in the year 2023 as observed and investigated by the researcher. These factors are that most teachers are not closely supervised and directed such that the teaching and learning of mathematics seems to have been characterized by rote memorization of some basic process and abstract presentation of facts and

principles. In addition, teachers' focus was on the monthly assessment which involves giving and recording of test results for promotion (Okolo, 2015). The assessment of students' progress and the ultimate level of achievement in schools is a very important part of any educational system. In education, the term assessment refers to the variety of tools which educators use to measure, evaluate and document the academic readiness, learning progress, skill acquisition or educational needs of learners.

The pedagogical transformation in the twenty-first century classroom has need for formative assessment approach that is more coherent and integrated. This is when changes are made in an existing idea. This is a process of introducing an assessment that existed, into a good and workable assessment that could bring about desirable achievement in both the educational system and the students. Formative assessment is a method of assessment applied into what existed for a better outcome. This is when an idea is replaced with a better one or involves more applications and initiatives with the aim of obtaining a desirable outcome.

This study is timely as the teaching and learning of Mathematics in the classroom have come a long way from teacher centered form to students and teachers collaborating to finding solution to the student's acquisition of required knowledge. In order for students to perform better in Mathematics and have the vision and mission of the 2030 Sustainable Development Goals (SDGs) achieved, the teacher could adopt Formative Assessment.

There are ten formative assessment strategies (Krisnaan & Idris, 2016). They provided crucial information about students' strength and weaknesses. Formative Assessment involves an ongoing classroom and questioning, discussions, quizzes, evaluation, assignments and tests that keep students and teachers informed of student's progress towards meeting learning objectives of the lessons (Okolo, 2015). The basic thing about Formative Assessment is that it is an assessment for learning and the common features are that it gives feedback and correction of error observed. Research has suggested that formative assessment could improve both learning and examination results and also reduces test anxiety (Svihla, 2006; Ajogbeje & Alonge 2012; Okolo, 2022). They reported that students who are systematically taught using formative assessment perform better than those taught using conventional methods. This study was carried out to investigate further the efficacy of the formative assessment in improving students' mathematics achievement.

Krisnaan and Idris (2016); Lee, (2018), discovered that using Formative Assessment consistently and effectively removes the students' surprises from getting final grades. They emphasized these approaches - Analyzing students work, Round Robin Charts, Strategic Questioning, 3-way Summaries, Think-Pair-Share, 3-2-1 count down, classroom Polls, Exit/Admit Tickets, One minute papers and creative extension projects. These approaches are used in appropriate questions on word problems. When integrated into teaching and learning on an ongoing basis, students can constantly improve and excel. This motivated the researcher to further investigate the efficacy in Junior Secondary School too.

In student-centered approach to learning, teachers and students play an equally active role in the learning process. Teacher's primary role is to coach and facilitate male and female students' learning and overall comprehension of word problems. In most cases, male and female students exhibit their strengths and weaknesses in Mathematics differently. In the area of gender and Mathematics performance research has been carried out by some researchers on male and female performance in Mathematics. Atovigba, Vershima, O'kwu and Ijenkeli (2012) found out that males perform better than female students in Mathematics. Other researchers, (Uche, 2012; Ajogbeje & Alonge, 2012) found no significant difference in the achievement of male and female students.

This study was built on the theories of learning hierarchy by Bruner (1968) and by Gagne (1979). These theories have had a profound impact on curriculum development and the methodology of teaching mathematics and science at both the primary and secondary school levels. Gagne postulated that learning is best achieved when teaching is organized from simple to complex. He suggested that concept acquisition takes place in an orderly, sequential, integrative and hierarchical manner, within the Formative Assessment. Efforts are also made by teachers before teaching concepts to ascertain the level of prior knowledge students had and to use that as prerequisite for new learning. Bruner's theory of learning by discovery promotes the acquisition of knowledge through discovery. This becomes necessary where the instructional strategy is learner- centered. Learners have to respond to the teacher's questions to enable them discover new ideas, theories and concepts in word problems. The lessons designed using the Formative Assessment are Learner- centered and taught in a manner that fosters deductive learning in students and improved their achievement in mathematics. There was therefore, the need for this study which was based on investigating the effect of formative assessment on junior secondary school students' mathematics achievement in two local government areas of Plateau State.

Research Questions

The following research questions were answered in the course of the study.

- (a) What are the levels of pretest and posttest mathematics achievement of JSII students in the control group?
- (b) What are the levels of pretest and posttest mathematics achievement of JS II students in the experimental group?
- (c) What are the Mathematics achievement mean scores of students in the experimental and control groups according to gender?
- (d) What are the pre-test and post-test mathematics achievement mean scores of JS11 students in the experimental and control groups?

Hypotheses

To facilitate this investigation the following hypotheses were formulated and tested at 0.05 level of significance.

- (a) There is no significant difference between the posttest mathematics achievement mean scores of students in the experimental and control groups.
- (b) There is no significant interaction effect of treatment and gender on the posttest mathematics achievement mean scores of students in the experimental group.

Methodology

This study adopted a quasi-experimental design, specifically the non-randomised pretest-posttest control group design. The choice of this design and its relevance to this study were based on the fact that it is an experimental study using intact classes. It also provides major controls against factors that could constitute a potential threat to the internal validity of the experiment. The selection was based on students in the same class of JS two suitable to study the word problem embedded within their curriculum. To avoid treatment contamination, the teachers teaching these students were also used as research assistants. The same teacher/research assistant taught both the treatment groups and the control groups. The testing procedures were the same within the four public schools and students that did not take the pretest were not used for the experimental study. Consequently, the provision of major control was introduced through the use of the equivalent schools such as a public

day junior secondary school and the classes such as JS two. Therefore, the sample which comprised intact classes was used in the schools of study to avoid disrupting the normal school programme. In other words, the characteristics of the students obtainable in the treatment group were the same with those of the students in the control group.

Population and Sample

The population for the study consisted of all public junior secondary class two (JS 2) students in Jos South and Barkin Ladi Local Government Areas of Plateau State which includes 33 public junior secondary schools from a population of 2,212 JS 2 students in public schools during the 2021/2022 academic session. The sampled schools were selected using stratified sampling technique. The choice of JSII students was because they were not in their final examination class. Moreover, the topic that the examiners reported to be difficult to the students was word problems and was within the JSII mathematics curriculum. Examiners of BECE (2022) also confirmed that students expressed weakness in questions related to word problems.

A sample of 240 JSII students in four public schools within Jos south and Barkin Ladi Local government areas of Plateau State were used for the study. The selection was done by a flip of a coin. Each of the classes that chose head became the experimental group while those that chose tail became the control group. The study used 121 student in the control group and 119 in experimental group consisting two arms each in each school. Altogether, the four schools had four intact classes used as experimental groups and four as control groups. Two public mixed schools from each of the local government area were selected.

Instruments

The following instruments were used in the study for data collection: Mathematics Achievement Test (MAT) are two structural alternate forms of 10 item essay tests adopted by the researcher from external examination questions from BECE. The test were for the pre-test and post-test. The (MAT) covered word problems within the JS II mathematics curriculum in addition; four essay items were constructed and administered to the students each week as a teacher made formative assessment tests feedback and remediation is given to the students immediately. When the test is given on a Friday the students get their marked scripts and results pasted on the following Monday. These were a total of 24 essay weekly test questions administered within six weeks of teaching. These essay questions were used for assessing student's understating of subject matter content and their ability to reason within their knowledge of the subject.

The content validity was established for the Mathematic Achievement Test (MAT). The appropriateness and comprehensiveness of the items were checked by the experts. These items were scrutinized and validated by one JSII mathematics teacher and one experts in research, measurement and evaluation unit for content validity. A formative validity was used to assess how well the instruments are able to provide information to help improve the investigation under study.

A test-retest reliability method and parallel forms of reliability were carried out. The results of the two tests were correlated to ensure that they were equivalent. The alternate form I and Form II tests were administered on other set of JS 11 students that were not used for the study twice, after an interval of two weeks. The stability, reliability and internal consistency and correlation of the equivalent form tests were obtained. The equivalent form reliability obtained was 0.89.

Four research assistants were trained by the researcher to assist in administering the instruments and teaching the topics selected for the study. The research assistants were teachers of mathematics in four junior secondary schools with B.Sc (Ed) or B.Ed. degree in mathematics with at least three years post qualification experience, as well as two years' experience in marking of BECE

mathematics. These qualities were necessary to ensure that these teachers had good knowledge of the subject matter and also possessed the professional qualification required for the successful conduct of the investigations. The four research assistants taught both experimental and control groups in the four schools.

A two day training programme was held with the research assistants. This training took place in one of the secondary schools in Jos South, Nigeria. The training programme was used for sensitization on the investigation and to acquaint the research assistants on how to use the Formative Assessment in the teaching and learning process.

Students in the experimental group were exposed to the instructional units using the designed lesson plan for six weeks. There were Formative Assessment Strategies applied during and after instructions to teach word problems aimed at checking if the students had achieved the set instructional objectives or not. At the end of each week, a four-item weekly test was administered; after each test, students were informed of their scores in the test. These tests were part of the formative tests used for feedback and remediation too. Discussions involving closer interaction among the students and between the teacher and the students to identify students' strength and weakness were employed. The researcher frequently visited the classes during the treatment session to ensure that the research assistants complied with the instructions within the manual. Students in the control group were not exposed to the Formative Assessment. They weretaught using the same topics with those in the treatment group but were subjected to Pretest and Posttest as well.

At the end of the six weeks of teaching and assessment the post-test on MAT Form II was administered to both the experimental and control groups, this was an alternate form of the test used for the pretest. The posttests lasted for one hour only. The scripts were collected after the posttest by the researcher who scored them personally using the marking scheme. The scripts were scored out of 100%. The students' mathematics achievement were therefore grouped according to high, average and low grades ranging from 70% and above-high, 50%-69%- average and 49% and below low grade.

The pretest and posttest results on the MAT were subjected to statistical analysis using frequency, percentages, mean, standard deviation and Analysis of Covariance (ANCOVA) techniques.

Results

Research Question one: What are the levels of pretest and posttest mathematics achievement of JSII students in the control group?

Table 1: Frequency and Percentage Distribution of Pretest and Posttest Mathematics Achievement Level of Students in the Control Group

TST	Achievement Level						Total	
	Low		Average		High			
	(49 &Below)		(50 – 69)		(70 &Above)			
	N	%	N	%	N	%	N	%
Pretest	115	95.0	6	5	0	0	121	100
Posttest	95	80.2	24	19.8	0	0	119	100
Total	210		30		0		240	

Efficacy of the use of Formative Assessment to enhance learning was investigated. Before the experiment the Mathematics achievement of JSII students in the control group ~~in~~ was very poor and there was slight increase for those who scored 50-69% from 5% to 19.8%. While (115)95% of the students scored 49 and below in the pretest, (95)80.2% scored the same low level achievement in the post test, there was no significant improvement in the students' performance within the control group as shown in Table 1.

Research Question Two: What are the levels of mathematics pretest and posttest mathematics achievement of JS II students in the experimental group?

Table 2: Frequency and Percentage Distribution of Pretest and Posttest Mathematics Achievement Levels of Students in the Experimental Group

	Achievement Levels						Total	
	Low		Average		High			
	(49% - below)		(50% – 69%)		(70 & Above)			
	N	%	N	%	N	%	N	%
Pretest	113	95	6	5%	0	0	119	100
Posttest	25	21.0%	64	53.8%	30	25.2%	119	100

The analysis of the result shows that the achievement of students before the treatment was very poor. From table 2, it revealed that 95% of students in the experimental group scored 49% and below in MAT, while 5% scored between 50-69%. After the treatment there was a remarkable improvement from no student scoring 70% and above to 30 scoring 70% and above (64)53.8% scored 50-69% while only (25)21% scored 49% and below. This indicates that 79% of the students scored 50% and above. The findings revealed that the use of Formative Assessment in the teaching and learning process enhanced the achievement of the students while those in the control group achieved low score.

Research Question Three: What are the Pre-test and Post-test Mathematics achievement mean scores of students according to gender?

Table 3: Analysis of Pre-test and Post-test Mathematics Achievement Mean Scores of Students According to Gender

	N	Mean	SD	Mean	SD	Mean Gain	Mean Difference
Male	116	31.95	8.93	48.34	17.78	16.39	1.59
Female	124	31.72	9.43	49.7	16.87	17.98	1.59

Table 3 shows the result of the analysis of the Pre-test and Post-test mathematics achievement mean scores of students according to gender. For the male students the post-test mathematics achievement mean score was 48.34 and standard deviation of 17.78, this is higher than the pre-test mean scores of 31.95 and standard deviation of 8.93. The mean gain between the post-test and pre-test of the male students is 16.39 indicating that there was an improvement in the mathematics achievement of male students after treatment. Also female students obtained post-test mean scores of 49.7 and standard deviation of 16.87 with the pre-test mean scores of 31.72 and standard deviation of 9.43 as well as a mean difference of 17.98. The findings revealed that the male and female students obtained a mean

difference of 1.59 which is not significant..Thus, one may conclude that the formative assessment that was used in teaching the male and female students improved their mathematics achievement equally. There is no difference between the results of the male and female students generally..

Research Question Four: What are the pre-test and post-test mathematics achievement mean scores of JS11 students in the experimental and control groups?

Table 4: Analysis of Pre-test and Post-test Mathematics Achievement Mean Scores of Students in the Experimental and Control Groups

	N	Mean	SD	Mean	SD	Mean Gain	Mean Difference
Experiment	119	32.03	8.84	60.75	13.24	28.72	22.91
al	121	31.7	9.52	37.51	12.28	5.81	22.91
Control							

Table 4 reveals the pre-test and post-test mathematics achievement mean scores of JS11 students in the experimental and control groups. In the experimental group the post-test mathematics achievement mean score was 60.75 and standard deviation of 13.24, this is higher than the pre-test mean scores of 32.03 and standard deviation of 8.84. The mean gain between the post-test and pre-test of the experimental group is 28.72 indicating that there was an improvement in the mathematics achievement of students after treatment. Students in the control group obtained post-test mean scores of 37.51 and standard deviation of 12.28 also the pre-test mean scores was 31.7 and standard deviation of 9.52 with a mean difference of 5.81. The findings revealed that students in the experimental group had a higher mean gain of 28.72 than those in the control group that had 5.81. This resulted to a mean difference of 22.91. This means that the use of formative assessment to teach the experimental group improved students' mathematics achievement in the experimental group while both the experimental and control groups performed poorly before the treatment.

Hypothesis

Hypothesis one: There is no significant difference between the posttest mathematics achievement mean scores of students in the experimental and control groups

Table 5: Analysis of Covariance (ANCOVA) of Posttest Mathematics Achievement Mean Scores of Students in the Experimental and Control groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	46251.197 ^a	2	23125.598	219.947	.000	.650
Intercept	9395.284	1	9395.284	89.358	.000	.274
PRE_MATH_A	13860.132	1	13860.132	131.824	.000	.357
CHI						
GROUP	31618.633	1	31618.633	300.725	.000	.559
Error	24918.536	237	105.142			
Total	648194.000	240				
Corrected Total	71169.733	239				

a. R Squared = .650 (Adjusted R Squared = .647)

Table 5 shows the Analysis of Covariance (ANCOVA) result to determine if there is a significant difference between the posttest mathematics achievement mean scores of students in the experimental and control groups. The Group result shows that $F(1, 237) = 300.725$, $p\text{-value} = .000 < 0.05$, partial eta squared = .650, since the $p\text{-value}$ of 0.000 is less than 0.05 level of significance the null hypothesis was rejected, indicating that there was a significant difference in the mathematics achievement mean scores of JSS II student between the experimental and control group after exposure to treatment. In addition, there is a positive strong relation with Adjusted R Squared of .647 which means that 64.7 percent of the variation in the dependent variable is explained by variation in the treatment using formative assessment, while the remaining 35.3% is due to other factors not included in this study. It indicates that the use of Formative Assessment was more effective on the experimental group against those of the control group. This shows that the use of Formative Assessment improved the performance of students within the experimental group while the mathematics achievement of those in the control group did not indicate any significant improvement. This further supports the assertion made earlier that regular use of formative assessment enhances learning and leads to improved performance of students in secondary schools.

Hypothesis Two: There is no significant interaction effect of treatment and gender on the posttest mathematics achievement mean scores of students.

Table 6: Analysis of Pretest and Posttest Mathematics Achievement Mean Scores of Students based on Gender

Group	GENDER	N	Mean	Std. Deviation
Pre-test	Male	116	31.95	8.93
	Female		31.72	9.43
		124		
Post-test	Male		48.34	17.78
		116		
	Female	124	49.41	17.35

Table 7: Analysis of Covariance (ANCOVA) of Interaction the Effect of Treatment and Gender on Mathematics Achievement Mean Scores of Students

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	46426.801 ^a	5	9285.360	87.814	.000	.652
Intercept	4046.934	1	4046.934	38.273	.000	.141
PRE_MATH_A CHI	13741.747	1	13741.747	129.959	.000	.357
GROUP	31567.826	1	31567.826	298.545	.000	.561
GENDER	174.120	2	87.060	.823	.440	.007
GROUP * GENDER	1.390	1	1.390	.013	.909	.000
Error	24742.932	234	105.739			
Total	648194.000	240				
Corrected Total	71169.733	239				

a. R Squared = .652 (Adjusted R Squared = .645)

Tables 6 and 7 show the interaction effect of treatment and gender on the post-test mathematics achievement mean scores of students. The post-test mathematics mean scores of male students ($M=48.33$; $SD=17.78$) and female ($M=49.40$; $SD=17.35$); $F(1,234) = .013$ and $p\text{-value} = 0.909 > 0.05$ level of significance, shows that treatment has significant interaction effect on gender in affecting post-test achievement in mathematics.

The group result shows that partial eta squared = .652 and since the $p\text{-value}$ of 0.909 is greater than 0.05 level of significance the null hypothesis was accepted, indicating that there was no significant difference in the mathematics achievement mean scores of male and female students after exposure to treatment. In addition, there is a positive strong relation with the Adjusted R Squared of .645 which means that 64.5 percent of the variation in the dependent variable is explained by variation in the treatment using formative assessment, while the remaining 35.5% is due to other factors not included in this study. The result reveals that the interaction effect of treatment and gender did not show any difference in the result of male and female students based on the result of their post-test mathematics mean scores after treatment. This further supports the assertion made earlier by Uche, 2012, on the belief that treatment does not account for variation in the results of male and female students in their mathematics achievement. We conclude that the use of the Formative Assessment improved the mathematics achievement mean scores of both male and female students in the experimental groups to high and average scores.

Discussions and Conclusion

The findings showed that the mathematics achievement of students before the treatment was very poor as all the students obtained low levels of achievement on the pre-test score in mathematics. The result revealed a significant difference between post-test mathematics achievement mean scores of students in the experimental and control groups. After the treatment, there was an improvement in students' mathematics achievement. The result of this study reveals that the use of formative assessment improves students' understanding of the concepts taught and the strategies employed improved their performance. This is in line with the findings of Okolo (2015; 2016; 2018; 2022) who stated that formative assessment helps to determine whether the teacher has taught what he is supposed to teach or whether what he taught has been learnt. It agree with the findings Stecher & Hamilton (2010); Alonge (2012) and Lee (2018) that students who are systematically (Experimental group) taught using formative assessment, perform better than those who are taught not using the formative assessment. We conclude that the use of the Formative Assessment improved the mathematics achievement mean scores of both male and female students in the experimental groups to high and average scores.

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