

ORIGINAL ARTICLE

Effects of Mastery Learning and Problem Solving Methods of Teaching on Students' Academic Performance in Mathematics in Zamfara State

Lawal Mohammad Mayanchi, Chidimma Adamma Anya, Mal. Ahmad Kainuwa
Department of Educational Foundations Federal University Gusau Zamfara State

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ABSTRACT

The performance of students in both internal and external examinations in Mathematics has been poor over years in Zamfara state. Poor mathematical skills and inefficient teaching methods have been identified as some of the major causes for the problem. Bloom's Theory of School Learning and the Principle of Mastery Learning asserted that virtually all students are capable of attaining a high degree of learning if given the appropriate conditions and exposed to constant practice associated with problem solving approach. The crux of this paper was to ascertain the effect of mastery learning and problem solving teaching approaches on Senior Secondary School Students' academic performance in some difficult topics in mathematics in Zamfara State. Quasi-experimental research design was used for the study. Four Secondary Schools were randomly selected and randomly assigned to experimental and control groups. A total of four hundred and fifty (450) students were used for the study. Data was collected using a 25-item Mathematics Achievement Test (MAT) made up of topics in probability perceived as a difficult topic. The instrument was pilot tested and Kuder Richardson formula 21 (KR21) was used to establish the reliability coefficient ($r = 0.83$). Pre-test was administered to both the experimental and control groups to ascertain if the three groups were comparable and have the same entry characteristics before the treatment. A post-test was administered to both groups after two weeks of exposing the experimental group to mastery learning and problem solving methods, these control groups also was exposed to traditional/ conventional (lecture) method. Data was collected to test the hypotheses raised for the study using Analysis of Variance (ANOVA). The mastery learning group had mean score ($\bar{x} = 15.25$; $s = 6.91$), problem solving group had a mean score ($\bar{x} = 12.26$; $s = 6.06$), greater than the control group ($\bar{x} = 10.50$; $s = 5.19$). The result which was significant ($F = 23.21$; $p = 0.00$), was further analyzed with Scheffe's multiple comparison test which showed a significant difference between all the pairs (MLA and PSA; MLA and control, PSA and control. But with mastery learning having the greatest mean score. Hence it was recommended as the most efficient of the teaching methods.

Keywords: *Mastery learning, problem solving method, students' academic performance, Mathematics, Gusau Metropolis*

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INTRODUCTION

Mathematics is a basic tool in the development of any science based knowledge for sound analytical reasoning in daily living in a modern society such as ours (Babalola, 1983). The Nigerian Government is quite desirous of achieving scientific and technological independence tried to introduce a number of innovations aimed at encouraging the learning of science in schools. As the nation is geared toward technological advancement, Mathematics as a vital subject has a role to play. It is therefore expedient that

Mathematics teachers know what to teach, when and how to teach. Not only that, to understand why students are having difficulty in passing Mathematics examination as well as how to stimulate interest in the subject. Hence, students need to be motivated to study effectively in order to achieve success (Usman, 2002). The Nigerian Mathematics curriculum is student centered; it emphasizes learning developmental needs and interest (Adedayo, 2006). However, evidence shows that students cognitive and affective domains in Mathematics fall below expectation (WAEC Chief Examiner 2012-2016). Stake holders have been making concerted efforts to ensure that these problems which are attributed to poor performances are detected through critical examination of students' selection of questions at terminal examinations (SSCE/NECO) and their general performance in the questions they attempted. It has been observed that students like avoiding questions in some particular topics during examination. There is need to identify some of the topics students fail or avoid and which teachers deliberately skip while teaching so that corrective measures can be taken. Some topics which are as perceived difficult or skipped are those students take as complex and cannot be easily solved. Adeleke (2007) conducted a study on topics preference of senior secondary students in Mathematics, she discovered that numbers and numerations, algebraic process and statistics were the most preferred topics while bearing and distances, probability and menstruation were the most disliked topics. Nnaji (1998) in another study found out that some topics which students perceived as difficult; namely: longitude and latitude, bearings and distances, probability, two-variables inequality, change of subject formula, arithmetic and geometry (sequence and series), number bases, graphs (linear and quadratic types) and set theory are the major difficult topics for the students. According to Akinsola (1987) some of the most common reasons for disliking Mathematics include rigidity and lack of creativity, anxiety of the students and poor teaching methods. He noted that when students mentioned difficulty and complexity of Mathematics as reasons for being uninterested, that means actually that Mathematics is difficult because:

- There are changes in the materials
- Old methods of leaning are not good any more.
- Introduction of new topics in the curriculum
- Phobia for the subject
- Difficulty in reasoning fast

However difficult topics have the following characteristics.

- They are not easily understood by most students and teachers too.
- They require more efforts and skills before a student can understand and solve them
- Few students attempt questions in them at SSCE (Adedayo 2006)

In education there are various methods of teaching whereby teachers could impact knowledge to their students. Prominent among these methods are: mastery learning method, lecture method, project method, demonstration method, discovery method, problem solving method etc. A good teacher should adopt any plan suitable to deliver his/her lesson.

Statement of the problem

The researchers observed that over the years, there has been consistent poor performance and high failure rate in Senior School Certificate Examinations in almost all the subjects in Zamfara state. Mathematics and English language which are the core subjects are the worst hit. Many students perform poorly in this subject due to one reason or the other; thereby limiting their career to progress further in their areas of interest. This is because many institutions of higher learning as well as professional bodies insist on a minimum credit pass in Mathematics for admission or employment. Another reason that makes this study very imperative and timely is the Chief examiners' report 2007-2016 analysis of SSCE results showed that averagely only a small proportion of candidates passed Mathematics at credit level throughout the examination period in Zamfara state as stated in Table 1.

Table 1: Statistics Performance in Mathematics for WAEC/SSCE Exam Results for Zamfara State from 2007 – 2016

Year	Total no of candidate who sat for SSCE		Total no of candidates who passed with credit level (1-6)		Percentage passed		Percentage failure	
	Male	Female	Male	Female	Male	Female	Male	Female
2007	8486	2000	2402	586	28.31	29.30	71.70	70.70
2008	9100	2486	2301	543	26.28	5.96	74.71	94.03
2009	10484	3100	3542	356	33.79	3.40	66.21	96.60
2010	12655	3210	3820	604	25.36	4.77	74.64	95.22
2011	14571	3300	2182	589	14.47	4.04	85.02	95.96
2012	20047	5000	5322	489	26.54	9.78	73.45	90.22

2013	20872	4000	3218	209	15.42	5.22	84.58	94.78
2014	20188	5000	5899	704	29.22	14.08	70.78	85.92
2015	18047	4000	4693	482	26.00	12.05	73.99	87.95
2016	19165	4300	5963	598	31.12	13.90	68.88	86.09

Table 1 shows Statistics Performance in Mathematics for WAEC/SSCE Examination in Zamfara State from 2007 – 2016. This analysis shows that averagely only a small proportion of the candidates passed mathematics at credit level and above.

Among the reasons identified by the Chief examiners for the poor performance are:

- Failure to apply correctly source Mathematical principles
- Inability to work to the required degree of accuracy
- Lack of basic manipulative skills
- Inability to visualize the component part of 3 – dimensional objects
- Lack of required skills in geometrical construction among others.

The poor performances may also be linked to the effects of negative attitudes towards the subject and poor methods of teaching some topics that student perceived difficult. Therefore, it is sad to note the sorry state of teaching and learning of Mathematics in the state. Hence, most students dislike and fail the subject. However concerted efforts have been made to remedy this ugly situation (Nnaji (1998), Olaoye (2002), Adeleke (2007), Adedayo (2006,) Akanni (2015) but up till now the situation has not been resolved. Moreover, from Table 1, it is evident that Mathematics as a core subject has not been placed in the table of subject successes. There is no gain saying that students' point at Mathematics with long sticks and many more have much difficulty solving Mathematics problems (Abakporo 2005). Again, majority of the students have irrational Mathematics phobia or fear for the subject and problem with anything figure or numbers. The need now arises that urgent and appropriate remediation is needed to reduce this massive failure thereby making the subject interesting to the students. This can be done by finding appropriate solution to areas or topics that students perceive difficult which the re-occurring topics in SSCE are causing massive failure in the subject. The results of the relevant intervention programmes would go further to remedy the situation.

The objectives of the study

1. The objective of this study is to assess the effect of mastery learning and problem solving methods of teaching in students' performance in some perceived difficult topics in Senior Secondary School Mathematics in Zamfara state.
2. To ascertain the significant interaction effect between treatments (teaching methods) and gender and performance in the post-test scores of the Mathematics Achievement Test (MAT) among Studnets in Zamfara state.

Research Questions

In order to achieve the objectives of the study the following questions are formulated:

1. Will there be any significant difference between the experimental and the control group in the post-test scores of the mathematics achievement test?
2. Will there be any significant interaction effect between treatments (teaching methods) and gender and performance in the post-test scores of the Mathematics Achievement Test (MAT).

Research Hypotheses

The following hypotheses are raised from the stated research question to allow statistical analysis:

1. There will be no significant difference between the experimental and the control group in the post-test scores of the mathematics achievement test.
2. There will be no significant interaction effect between treatments (teaching methods) and gender and performance in the post-test scores of the Mathematics Achievement Test (MAT).

The mastery learning approach was developed by Bloom (1968). It was based on a theoretical model developed by Carroll (1963) which states that the degree of learning acquired by a learner is proportional to the time spent on the learning, divided by the time needed for the learning. The model is based on the assumption that instructions will be of good quality and appropriate for the students. If instruction of poor quality is given more time which will be needed to master the learning. Bloom's development of mastery learning approach from this model operates on the proposition that almost every student can learn the basic skills that form the core of the school curriculum when the instruction is of good quality and appropriate for the learner. Advocates of mastery approach have proposed that almost all students can acquire adequate levels of the basic skills taught in the normal school curriculum when mastery procedure are used (Bloom, 1971). The student who performs at the minimum pass level on the summative evaluation in a course is evaluated as one who has performed successfully in the course and is

fit for the next course on the programme. Bloom and his students conducted many empirical studies that showed that mastery learning programmes are very effective in a wide variety of situations (Levine, 1985). Babalola (1991) investigated the mastery learning model in teaching mathematics to form four students by a non-expert mathematics teacher. He found that a group taught by mastery learning approach performed significantly better than those taught by non-mastery approach. He therefore, suggested further research in the area particularly with respect to the use of the mastery learning approach in a normal classroom situation by qualified and non-qualified mathematics teachers. Other researches on mastery learning in schools have also shown positive cognitive learning outcomes in students (Akinsola, 2007, Aderemi, 2006). Abadom (2002) reported that results of studies using Bloom's learning for mastery (LMF) approach showed that the mean score for the mastery learning group is usually at least one standard deviation higher than the mean score of the conventional teaching method group. This agrees with Adeyemi (2007) who studied the effectiveness of learning social studies through mastery learning approach on students' performance in social studies using two groups of 200 level students from a University in Nigeria and a study centre of the same University. He found that students taught with mastery learning in the two groups performed better than students taught with the conventional approach to teaching. Another study was conducted by Ogan (2012) on the effect of mastery learning on senior secondary school achievement in Geography and he found that the mastery learning group performed better than the control group (conventional teaching method). Majidat (2002) also did a study on mastery learning titled, 'effects of three instructional strategies on cognitive learning outcome of students in mathematics' and found that mastery learning was very effective in enhancing students' performance irrespective of their sex. Patricia and Johnson (2008) studied the effects of mastery learning approach and gender on students' achievement in physics using two groups of students in co-educational schools. One group (experimental) was taught with mastery learning approach and the other group (control) was taught with conventional teaching method. They found that the group taught with mastery learning achieved better than the group taught with the conventional teaching method. They also found that there was no significant effect of gender on the achievement of the students and concluded that mastery learning is an effective teaching method, which physics teachers should be encouraged to use. Ogba (2000) studied the effect of mastery learning on cognitive learning outcomes of junior secondary school mathematics and found mastery learning better than conventional teaching method. Problem solving is both a goal of learning Mathematics and a means of doing so (Riasat, Hukamdad & Akhter, 2010). It allows students to exploit, develop and apply their understanding of Mathematical concepts (Polya, 1957). The primary goal of problem solving approach is making sense of Mathematics. Here teachers have responsibility to promote the experiences of problem solving processes in their classrooms and to foster in their student a positive attitude towards problem solving. According to Abakporo (1991), problem solving is not only a goal of learning Mathematics but also a major means of doing so. Problem solving should be the Master of mathematical teaching and should be used daily as a basis for mathematical instruction. Problem based learning is a model which centered on students, develops active and motivated learning, problem solving skills and broad field knowledge, and based on the deep understanding and problem solving. (Major et al, 2000). In those classrooms in which problem based learning method is used for instructional process, the students take much more responsibility of their own learning. They have become independent and long life learners, and can continue to learn in their whole life. Presenting the students with a problem, give them opportunity to take risks, to adopt new understandings, to apply knowledge, to work in context and to enjoy the thrill of being discoverers. Tick, (2007) stated that in the student-centered learning environment that is desirable for problem based learning; the central figure of the learning-teaching process is the student. The learning objective is not the reproduction, recall and learning of passively received learning material but the active and creative engagement of students in group work and in individual study thus transferring the skills and knowledge. The individual, autonomous self-directed learning gives the freedom to the learner to decide individually and consciously on the learning strategy and on the time scale, He/she wants to follow. Riasat, Hukamdad & Akhter (2010) carried out a study using 86 Pakistanian high school students in 8th grade on effects of problem solving technique and traditional methods of teaching on mathematics achievement. It was also found that the academic achievement of the students was better who were taught through problem solving method as compare to the students who were taught through traditional method.

Concept of Modern Teaching Approach

The teaching of Mathematics in Nigeria is characterized by the traditional formula based approach with emphasis on computation and little reference to mathematical reasoning and problem solving. Teaching is done mechanically by the teacher, first presenting a formula or rule or algorithm, then solving some textbook examples, and finally given some exercises for students to solve. For instance in teaching the

perimeter of a sector = $2r + L$ units, where r is the radius and L is the length of arc. You then solve some examples, and finally give class work from textbook.

This type of teaching is mechanical and teacher centered. It is obsolete since in that approach, Mathematics is learned instrumentally by rote memorization without meaningful understanding of the concept taught. This way student becomes frustrated in the face of apparently meaningless symbols that are manipulated. They regard Mathematics as a static subject with a set of algorithms to be applied mechanically carryout/undertake mathematical exercises/drills. In contrast to this traditional approach, the modern method of using mastery learning and problem solving approach is learner – centered or child – centered and activity based, aim at helping the learner to develop and construct a meaningful understanding of the mathematical concept taught whether difficult topics or easier ones.

MATERIAL AND METHODS

The study adopted quasi-experimental pre-test/ post-test control group design (Campbell & Stanley, 1963).The study was carried out in Gusau metropolis. It is the intention of the researchers that the study will help to increase the achievement in mathematics and consequently enhance their performance. The target population for the study is the entire senior secondary school students of Gusau. Four hundred and fifty students (450) were selected by the use of stratified random sampling. The sample for the study also consists of 225 males and 225 females. There were three groups made up of two treatments and one control group. One group was taught with mastery learning, the other with problem solving method while the control was taught with conventional method.Data was collected using a 25-item Mathematics Achievement Test (MAT).Covering the concept of probability perceived as one of the difficult topics drawn from past WAEC questions. The instrument was pilot tested and Kuder Richardson formula 21 (KR21) was used to establish the reliability coefficient ($r = 0.83$). Pre-test was administered to both the experimental and control groups to ascertain if the two groups are comparable and have the same entry characteristics before the treatment. A post-test was administered to both groups after two weeks of exposing the experimental group to mastery learning and problem solving methods and the control group to conventional (Lecture) teaching method. Data collected were analyzed using descriptive statistics and Analysis of Variance (ANOVA)

RESULT

H_{01} . There will be no significant difference between the experimental and control groups on the post-test scores of MAT.

Table 2: Descriptive statistics of mean and standard deviation for the post-test scores in Mathematics Achievement Test (MAT)

	N	Mean	Std. Deviation	Std. error
Mastery learning	150	15.25	6.91	.5644
Problem solving	150	12.26	6.07	.4945
Control	150	10.51	5.19	.4237
Total	450	12.67	6.39	.3011

The result in table 2 shows an improvement in the experimental groups which is obtained in the control group. This can only be ascribed to the teaching methods that the treatment groups were exposed to assuming that all other factors are held constant and common to both groups. It can be inferred that the treatment given to the experimental groups must have been better than the method given to the control group. This can be confirmed through the use of ANOVA test.

Table 3: ANOVA table of differences between post-test scores in MAT

	Sum of squares	df	Mean square	F	Sig.
Between groups	1723.098	2	861.549	23.205	.000
Within groups	16596.227	448	37.045		
Total	18319.324	450			

The result in Table 3 indicates that F_{cal} of 23.205 is significant, which means that hypothesis 1 is rejected, therefore; there is a significant difference between the experimental groups and the control group in the post-test scores in MAT. A confirmatory test to show the significance between the pairs of groups using Scheffe's multiple comparison tests was carried out in Table 4.

Table 4: Scheffe Multiple comparison test

		Mean Difference (I-J)	Std. Error	Sig.
(I) Type of treatment	(J) Type of treatment			
MLA	PSA	2.9867	.7036	.000
	CONTROL	4.7400	.7036	.000
PSA	MLA	-2.9867	.7036	.000
	CONTROL	1.7533	.7036	.000
CONTROL	MLA	-4.7400	.7036	.000
	PSA	-1.7533	.7036	.046

The result in Table 4 indicates that there is a significant difference between all the pairs: MLA and PSA, MLA and control, PSA and control, with Mastery learning having the greatest mean score. Hence recommended as the most efficient of the teaching methods.

H_{02} : There will be no significant interaction effect between treatments (teaching methods) and gender and performance in the post-test scores of the Mathematics Achievement Test (MAT). In order to investigate the level of interaction effect between gender and treatment of the post-test scores of the students' Achievement in mathematics, ANOVA was applied. Before then the descriptive data was obtained.

Table 5: Descriptive data on gender and treatment

	Value label	N
Gender	Male	225
	Female	225
Type of treatment	MLA	150
	PSA	150
	CONTROL	150

Table 5 indicates the descriptive data of both gender and treatment. ANOVA statistics was also applied to verify if there is interaction effect between gender and treatment on the student's achievement in mathematics. The result is presented in table 6.

Table 6: Two way Analysis of variance showing gender and treatment interaction effect.

Source	Type 1 sum of squares	Df	Mean square	F
Model	75894.773	6	12649.129	382.70
Gender	72310.444	2	36155.222	1093.88
Treatment	1723.098	2	861.549	26.07
GENDER+ Treatment	1861.231	2	930.616	28.16
Error	14675.227	444	33.052	

Table 6 shows a significant F_{cal} of 28.16, which means that there is a significant interaction effect between gender and treatment in the post-test scores of students' achievement in mathematics.

Findings

1. There is a significant difference between the experimental groups and the control group in the post-test scores in MAT. This indicated that the treatment given to the experimental groups must have been better than the method given to the control group.
2. There is a significant interaction effect between gender and treatment in the post-test scores of students' achievement in mathematics.

DISCUSSION

The results obtained in table 2 to 5 indicated an improvement in the experimental groups which is obtained in the control group. This result is in agreement with the findings of mastery learning in schools having also shown positive cognitive learning outcomes in students (Akinsola, 2007, Aderemi, 2006). Abadom (2002), Adeyemi (2007), Ogan (2012), Majidat (2002) Patricia and Johnson (2008) and Ogba (2000) who in their independent research studies supported mastery learning approach in the teaching and learning of mathematics. Consequently, the result also is in conformity with Riasat, Hukamdad&Akhter (2010) and Akanni (2009) who also achieved the same result using problem solving method with their individual sample characteristics.

Moreover, when the two treatment groups and gender were analyzed for possible interaction effect, the result also showed a significant difference between the treatments and performance. This also proved the efficacy of the treatments on the performance of students in Mathematics. However, the post- hoc comparison in this study indicates that the mastery learning approach is a better teaching method than the problem solving method.

CONCLUSION

The paper examined the dilemma associated with poor performance in Mathematics in Gusau Metropolis of Zamfara state. It raised the issue that among the causes of poor performance in the subject is that some perceived difficult concepts in the subject were either avoided by the teachers or not taught well as a result of not applying better approaches to teaching the subjects. The paper therefore applied mastery learning and problem solving methods of teaching and discovered their efficacy over the conventional method.

RECOMMENDATIONS

Based on the findings of the study, it was recommended that classroom teachers should adopt Mastery Learning and Problem Solving Teaching methods in the teaching and learning of difficult concepts in mathematics. In addition the teachers should try to make the teaching of mathematics as learner-centered grouping system. The conventional (Lecture) method should be discouraged especially in mathematics teaching. Stakeholders should equip schools with modern infrastructure to accommodate the teeming population. Co-education should be encouraged in Zamfara schools, to boost the morale of the male students and to encourage them to work harder.

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