EFFECTS OF MATHEMATICAL MODELING ON STUDENTS' PERFORMANCE IN MATHEMATICS AT UPPER BASIC LEVEL OF EDUCATION IN BAUCHI METROPOLIS OF BAUCHI STATE, NIGERIA

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Abstract

This article is based on a quasi-experimental designed study, was aimed at establishing the effect of mathematical modeling on the Nigerian Upper basic two students' performance in Mathematics in Bauchi Metropolis of Bauchi State Nigeria. The instrument used for the study was Mathematics Word Problem Solving Test (MWPST). Data from the student's achievement test (MWPST) was coded and analyzed using Statistical Package for Social Sciences (SPSS) version 17. Means, variance, standard deviations, an independent sample t-test and Analysis of Variance (ANOVA) were used to test the null hypothesis at 0.05 level of significance. Pre-test findings based on independent sample test revealed insignificance difference at (t(203) =0.919, ρ = .326, α = .05 where p>0.05) between experimental (E1) and control group (C1)in students' performance in word problems. The result was expected as it indicated student similar performance in words problems prior to the intervention. Based on the design also, further findings on posttest result revealed a significance increase on students' performance in words problems as experimental groups (E1 and E2) had higher means performance compare to control groups (C1 and C2). On establishing a significance difference between experimental groups and control groups, ANOVA posttest result in word problems revealed a significance difference at (F (417) = 48.63 p = .01, α = .05 where p<0.05))between experimental groups and control groups in learning words problem. The results in this study illustrate that mathematical modeling can be used to improve students' performance in word problems. The implication is that learners seem to have exhibited their chances of learning Mathematics, a tool needed for the transformation of the Nigerian economy from a developing economy.

Keywords: Mathematical modeling, gender, performance, upper basic school mathematics

Introduction

The upper basic (junior) secondary school Mathematics curriculum is design to serve as a linkage between primary and secondary mathematics curriculum. One of the important strands of the junior secondary school curriculum is algebraic word problems which feature through secondary mathematics (Dogo, 2012 & Ladele, 2013). To be successful in solving word problems, students need to learn how to read, comprehend and represent such word problems algebraically in their second year in secondary school as they transit from arithmetic to algebra (Barwell, 2011 & Ladele, 2013).It also requires teachers to be skilled at teaching in ways that are effective in developing mathematics learning for all students.

Andam et al (2015) pointed out that learning is effective when the learner has the opportunity to content with tasks, think about the solution, employ strategies to solve and evaluate the result. Mathematics learning should then focus on developing understanding of concepts and procedures through problem solving, reasoning, and discourse (NCTM, 2012). Student 'understanding is deepened when both the language of instruction and the method used by teachers provide the discussion of similarities among representations that revealed underlying mathematical structures or essential features of mathematical ideas (Zimba, 2011).

Studies have also indicated that when teachers are unable to correctly conceived the language use in teaching a new concepts and the required strategy, it might lead to student's misconceptions and mistakes in learning algebra word problems problem-solving. (Welder, 2012). As leaners failed to engage in mathematics word problems, they are likely to experience low performance in mathematics. Students' low performance in mathematics limited their chances in studying advance mathematics.

Benson and O'Oconnor (2015) in their study on effects of mathematical vocabulary instruction on students' achievement in Mathematics in Secondary Schools of Murang'a County, Kenya found that students poor performance at the national examination (KSCE) would be as a result of their in ability to comprehend mathematics vocabulary and the language of instruction. For students to excel, they must recognize, comprehend and apply the requisite mathematical vocabulary.

Musa and Dauda (2014) in their study on trends analyses of students' mathematics performance in West African Senior Secondary Certificate Examination from 2004 to 2013; implication for Nigeria's vision 20:2020 found that performance pattern was unstable over time and that performance rates indicated that less than 50% of the candidates passed at credit level in Mathematics over the reviewed period. By implication mathematics performance in Nasarawa State has been persistently poor over the years reviewed similar to what has been reported for the whole nation and could continue from 2014 to 2020 based on the forecast.

Uchechi (2013) submitted that students' poor performance in Mathematics in Nigerian public examinations is traceable to lack of content coverage and poor teaching methods by teachers. The resultant effect is the poor performance and low retention level in leaners achievement at the national and international examinations. Dogo (2017) in a study on effects of English Language on junior secondary student's performance in mathematics in Nigeria pointed that, the poor performance of students in mathematics may not be unconnected to the text language and teachers approach in teaching the subject.

Interest for this research is triggered by the researchers concern about students 'poor academic performance in General mathematics and specifically algebraic word problem. The persistence difficulties in learning algebraic word problems may arise from the language of the problem, generalizations involved and the use of letters to change to mathematics (equation) which differ from everyday use that students know (Joseph &Kurumeh, 2011). Mathematical Modelling therefore is used to promote student's engagement, discussion and making an algebraic expression from the real-life situations (Anhalt& Cortez, 2015). Students are to develop ideas and representation and eventually lift those ideas in solving related problems.

Mathematical modeling is not only a relatively new concept to mathematics teachers in Nigeria but also it is true that the level of mathematics teachers' preparedness to undertake the task of implementing and facilitating modelling activities in the classroom become less construct and uninterested. This study therefore, sought to find out if mathematical modelling approach would make word problems easier to be solved and comprehend by the Nigerian junior secondary school students.

Objective of the study

The study was guided by one objective as follows;

1. To find out the effect of mathematical modelling on students' performance in mathematics

Research Question of the study

Only one research question was formulated for the study and was presented as follows;

1. What is the performance level of upper basic two students in solving word problems?

Hypothesis of the Study

The study was guided by a null hypothesis and was tested at significance alpha level of 0.05.

Ho1: There was no statistically significant difference on effect of mathematical modeling on students' performance in word problem between experimental and control groups.

Theoretical framework

The study was guided by constructivism theory and was developed by Vygotsky, 1978. Constructivism theory believes that an individual develops his reasoning with the pattern he sees (Major & Mangope, 2012). The classroom is a constructed place which is situated in a society. This is where a professional teaching and learning take place and are made available for each individual to internalize and construct knowledge that is useful in the learning of mathematical concepts.

In this theory, also, the learner is responsible for the construction of his knowledge, through the interaction of new ideas with his prior knowledge (Major & Mangope, 2012). A mathematical modelling therefore, functions as an intellectual tool during the process of learning mathematics and particularly word problems where a learner can read, comprehend, transform, operate, formulate and produce a solution to a given problem.

Conceptual Framework

The mathematical modelling approach which is independent variable, intervening variables are teachers and the students the dependent variable is the learning outcomes (students'

performance). The interaction between these variables was the outcome of the study. Figure presented the conceptual framework for the study.

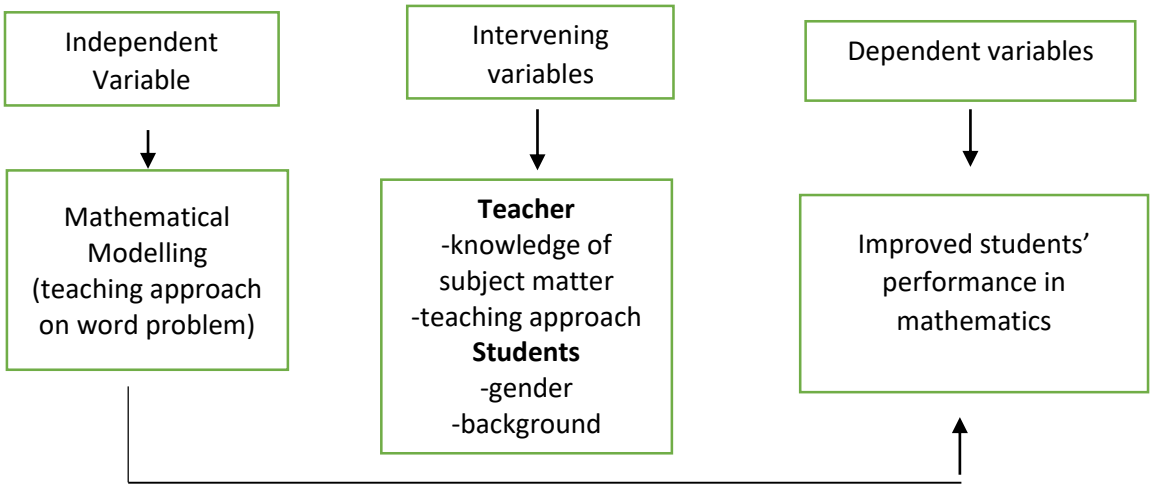


Fig 1: Conceptual framework (the researchers)

Research Method

Research design

The study used quasi-experimental research design. The quasi-experimental design used was based on the Solomon Four – Group Design, where various combinations of tested and untested groups with treatment and control groups exist. These allow the researcher to ensure that confounding variables and extraneous factors have not influenced the results. This design also ensures the effectiveness of the treatment on the variables, and allows whether the pre-test have effect on the subjects (White & Sabarwal, 2014).

Solomon four group design involve two experimental groups (E1 and E2), and two control groups (C1 and C2). A pre-test and post-test was administered to both groups, but only the experimental group received treatment. Within each treatment condition, there was a group that was pretested and the one that was not, but all the groups were then post-tested. The design can be represented diagrammatically as shown in the table below

Table 1: Solomon Four Group Design

Group		Pretest		Treatment	Posttest
R	E1	O1	X1	O2	
R	C1	O3		O4	
R	E2		X2	O5	
R	C2			O6	

Source: Braver and Braver 1988.

Sampling Procedures

The sampling category was the upper basic secondary schools and not individual students since students operate as intact groups. The study used only boarding secondary schools (upper basic level) to ensure that students involved in the study had academic abilities that were comparable. Purposive sampling technique was used select four schoolsfrom the study

area in Bauchi metropolis ofBauchi state Nigeria. The sampled schools were far apart and this was to reduced interaction among students which may likely affect the impact of the treatment.

Sample Size

In each school, there were at least two Upper Basic two arms. All the students in each class from each school were considered as sample in the study. The number of students in each group from the boarding schools forms the sample of the study. An intact class can use to form the sample of the study particularly an experimental study and provided the number students can represent the entire population. The total number of students found in the study schools were 420, the sample number the form the sample for the study.

Instrumentation

The students' achievement test used was the mathematics word problem solving test (MWPST). The test instrument used was adopted from Newsman performance strategies (Newsman, 1983b. p.). This procedure required students follow procedures (Mathematical modeling approach) in getting solution to the algebraic word problems. The instrument used 10 items drawn from students' JSS 2 mathematics syllabus. The test instrument was pilot tested to ensure its reliability using a Crombach Alpha coefficient at 0.05 which was found to be 0.82. It was thus accepted as a reliable measuring tool.

Training of teachers on the template (Mathematical Modelling Approach)

Five teachers who were available and from the experimental schools were trained by the researcher on the new approach (MMA). This was to ensure that teachers are acquainted with the new strategy. The training was conducted 5 hours daily for 5 working days for at least three weeks in August, 2015.

The training has focused on algebraic word problems on areas such as; age, group, combine and compare aspect of words problems; these were selected from the JSS 2 mathematics content specifically on word problems. Teachers were required to use the new strategy (MMA) for students to formulate and develop relevant equation to solve related word problems. Figure 1 presented the modified mathematical modelling.

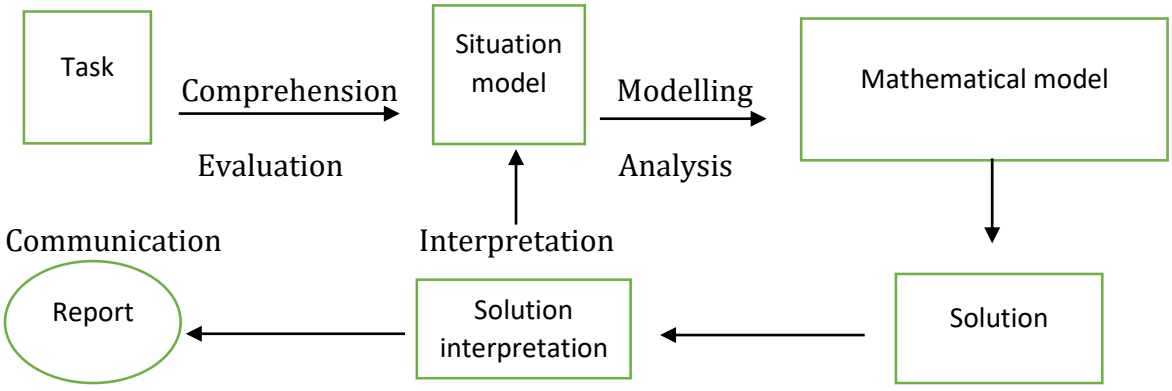


Fig 1: Modified Mathematical Modelling Approach (Researcher).

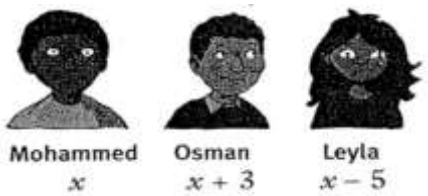
Figure 1 shows modified mathematical modelling procedures that were used by experimental teachers in the study. The use of procedures showed how teachers guided the students toward getting solution to identified task or problems and this was used as follows

1. Comprehension process. The arrow shows how leaners through the guidance of their teachers read the entire problem and picture what it's about and rewrite the problem in a sentence form.
2. Modelling process. The arrow indicated how the lesson teachers guided the learner determine who and what is involved, write down what the problem was talking about.
3. Mathematical analysis. The arrows show how the lesson teachers guided leaner on how to set the word problem into an equation form, using relevant operation to enable them solve the problem.

The researcher further developed a template for the training of teachers on the above approach. This was possible to indicate a paradigm ship from the normal practice. The motive behind the development of the template was to enable mathematics teachers particularly from the experimental groups be acquainted and be familiar with the new strategy. Figure 2 presents the mathematical modeling template as follows.

Mathematical Modelling Lesson Plan Template (MMLPT).

CLASS: JSS2 **Subject: Mathematics**

Date	**Time**	**Topic/ Subtopics**	**Objectives**/PCK	**Teaching/LearningActivities Teacher/Leaner activities Keywords**-age, older, younger etc	Learning Outcomes
17/06/22016 Tuesday	8:00am	**Topic** Words Problems **Subtopic** Age word problems	By the end of the lesson, leaners should be able to; i. find the age word problems in terms of addition and subtraction PCK Addition and subtraction integer word problems	**Introduction (5mins)** Teacher gives the following problems **Problem 1** Osman is three years older than Muhammad. Leylia is 5 years younger than Muhammad. How old is Osman when Muhammad is 10 years? **Activities** Step1 (reading and comprehension):3mins The teacher read the question and ask the student read the question repeatly Step 2 (representation): 5mins The teacher guides the students represent the problem statement with unknown variables for mathemazation as; Let x = Muhammad Let x+3 = Osman age (older) Let x_3 = leylia age (younger **Step 3 (5mins)** The teacher use pictures or materials  Step4 (solving) The teacher guides the students to solving the problem Osmand age x+3 = 10+3 = 13 since x =3	Comprehension (ability to read) Transformation ability and modeling abilities Solving skills or abilities

				Osmand age = 13 Step 5 (Evaluation): 3mins The teacher guide learners proof solution **Conclusion-**students class work	Ability to evaluate

The above developed template was only mean for teachers of experimental groups of which they were trained based on the modified mathematical modelling. Teachers from the control schools were only required to do their normal teaching in learning word problems. There was no specified strategy for teachers to follow. The teaching also focuses on the same JSS 2 mathematics contents (word problems). This was to ensure that teachers work within the same scope of the study. Digital cameras and tapes were used to record the conversations and then transcribed by the researcher himself in all the groups.

Data collection

Prior to the training or intervention on the treatment, students' achievement test (MWPST) developed by the researchers was given to the same categories of students as a pre-test using Solomon Four groups design procedures. In the pre-test, only the experimental group (E1) and control group (C1) was tested. This was to examined and ensured their level of problem solving skills before the intervention.

After the intervention, similar test instruments (MWPST) was used as students' post-test for the entire four groups (E1, C1, E2, and C2). The students' instrument was marked and scored using Newsman performance scoring procedures (Newsman, 1983b). In these procedures there are five steps and in each correct step, a mark was awarded. The total marks per item were 5. This implies that marks ranges between 0 and 5 per item. Each student's scores were coded and analysed using SPSS version. The post-test was given to ensure whether any changes have occurred between the pre-test and post-test student's achievement test.

Data analysis

Data were analyzed using both descriptive and inferential statistics. Percentages, mean and standard deviation were computed to test the research question for the study. T-test and Analysis of Variance (ANOVA) were used to analyse the stated null hypothesis. Differences in means of the post-test scores for both control and experimental groups were investigated. It was used to determine whether the differences were significant. A t-test was used when dealing with two means because of its superior power to detect differences between two means. Significance level of 0.05 was used to test the null Hypotheses.

Result

Hypothesis: There was no statistically significance means difference on students' performance in word Problems between control and experimental group. The study employs quasi-experimental design with particular emphasis on Solomon-four group design. Considering the design, students' performance was obtained before and after the intervention. Only Experimental group (E1) and Control group(C1) were tested and performance obtained prior to the intervention, this kind of analysis is acceptable based on the design (Borg & Gall, 1989). The mean scores for the two groups (E1 and C1) were computed using the SPSS Program. Table 1 present the result.

Table1 (pre-test)
Table 1: Students' Performance in the Pre-test MWPST by Groups.

Group	N	M	S D.	S.E of Mean
E1	105	9.68	8.263	.55210
C1	100	8.85	7.234	.52404

Table 1 reveals a statistically insignificant difference in the mean scores of pre-test MWPST for the experimental (E1) and control groups (C) at t (203) =0.919, ρ = .326, α = .05 where p>0.05 This is a clear indication that students 'performance in the pretest was similar and their level of understanding word problem was also the same. Thus, the hypothesis which stated that, there was no significant difference on the effects of mathematical modelling on students 'performance was retained. This finding agrees with Njoroge&Githua (2013) which in their study found that there was no statistically significant between experimental and control group difference in the pretest Mathematics Achievement Test (MAT)prior to the to the commencement of the intervention on Cooperative Learning Strategy (CLS).

To further investigate the same stated objective and hypothesis, a posttest was also administered to all students under the study. In this investigation, the researcher also employed the Solomon four group designs where all groups experienced the posttest. The post-test MWPST contained 10 items which were also scored based on Newsman (1983a) performance strategies. Table 2gives the mean score of students 'performance in the posttest MWPST.

Table 2: MWPST Post-test Mean Score obtained by the Students in the 4 Groups

Group	N	M	SD	Std Error
E1 (1)	105	2.69	1.17	.11429
C1 (2)	105	1.50	.87.	10120
E2 (3)	105	2.19	1.10	.08631
C2 (4)	105	1.09	1.05	.10454

Table2 shows that students of experimental group E1have better performance (M= 2.69, SD = 1.17) than control group C1 (M=1.50, SD = .87) in the post-test MWPST). It also reveals that experimental group E2 have better performance (M= 2.19), SD = 1.10) in the pot-test MWPS. This is a clear indication that experimental groups E1and E2 who were exposed to mathematical modeling approach have shown a better performance than the control groups C1 and C2 respectively. The implication here is that when learning word problem through mathematical modeling, students 'performance in learning mathematics would increase. In support of these findings Lesh and Zawojewski, (2007) view that engaging students in mathematical modeling activities would help them arrive at mathematical ideas in problem solving, and hence performance increased.

To test hypothesis one (H01) which states that there is no statistically significant means difference in the effect of English Language on junior secondary school student's performance on word problem, Analysis of Variance (ANOVA), was also carried out on posttest MWPST scores. Table 3. gives the result of the ANOVA of the difference in the post test MWPST scores

Table 3: ANOVA Post-test Results of MWPST between the 4 Groups

	Sum of Sqrs	df	Mean score	F	p-value
Between groups	155.14	3	51.712	48.63	.000
Within groups	427.46	417	1.063		
Total	582.594	420			

Table 3 shows that there was a significant mean difference in the student performance in the posttest MWPST between the 4 group (F (417) = 48.63 p = .01, α = .05 where p<0.05). The study thus concluded that using mathematical modeling in learning algebra word problem increase students of mathematics. Therefore, the hypothesis (H01) which states that, there was no significance difference on effect of mathematical modeling on students 'performance was rejected. Since this result was statistically significant.

Discussion

Findings on hypothesis one revealed an independent sample t-test of pretest with in significance means difference on students' performance in words problems (table1). Thus the hypothesis which stated that there was no significance means difference on performance between experimental and control group was retained. Result indicated similar performance between experimental (E1) and control group (C1) prior to the intervention. The expectation of this finding was possible since the students had common knowledge of word problem before the intervention.

Further findings revealed Post-test (MWPST) mean score obtained by the students in the 4 groups. Result indicated a significance increase on students' performance in learning words problems (table). This is a clear indication that experimental groups E1and E2 who were exposed to mathematical modeling approach have shown a better performance than the control groups C1 and C2 respectively. In support of these findings, Benson & O'Oconnor (2015) view that engaging students in mathematical modeling activities would help them arrive at mathematical ideas in problem solving, and hence performance i

On finding out the significance means difference in performance in solving word problem among students, an independent t-test MWPST was also carried out using the same group of students. These groups (E1, C1, E2and C2) where categorized into experimental group (E1 and E2) and control groups (C1 and C2). A posttest result was obtained and ANOVA results of the same post-test between the 4 groups was obtained. It revealed a significant means difference in the student performance, F (417) = 48.63 p = .01, α = .05 where p<0.05. By implication result indicated that using mathematical modeling in learning algebra word problem increase students' performance in learning mathematics. Adegoke (2013) in his study on structural regression modelling of bilingualism and achievement in mathematics among senior secondary school students in Nigeria reported a similar finding. The structural model showed that the relationship between Proficiency in English language and mathematics achievement was high and positive. This finding agrees with Benson (2015) whos study showed Effects of Mathematical Vocabulary Instruction on Students' Achievement in Mathematics in Secondary Schools of Murang 'a County, Kenya found no significance difference on gender performance.

Implications of the study

The performance of students in mathematics at WAEC/SSCE and JSSCE over the years continue to remain very low and below fifty per cent. Since findings from the study indicated significance increased in the overall students' performance in word problem, then it has shown that students understanding of word problems, thus the strategy (mathematical modelling approach) has positive effect on their performance in mathematics. Therefore, if MAA teaching method is effectively used by Mathematics teachers in secondary schools, more students will better understand mathematics and will have access to advanced Mathematics courses which are useful for the Nigerian economic growth and stability.

Recommendations

From the conclusions of the study, recommendations were made and areas of further study were suggested.

1. The integration of Mathematical Modelling approach is the best method since it is learner centered, it would enhance high proficiency of the text language and lead to relational understanding of mathematical concepts.
2. Junior Secondary school mathematics teachers should be acquainted with the new strategy as it would also enhance their pedagical content knowledge.

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