



Effects of mathematical modelling performance in mathematics by gender among junior secondary schools students in 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 modelling on the Nigerian junior secondary schools two students' performance in mathematic. The instrument used for the study was students achievement test (MWPST). Data from the students achievement test (MWPST) was coded and analysed using Statistical Package for Social Sciences (SPSS) version 17. Analysis of Variance (ANOVA) and independent t-test were used to test the research question at 0.05 level of significant. Pre-test findings revealed gender bias in students' performance with word problems in favour of the male gender. The findings after the intervention of the mathematics modelling indicated a reduced gap in performance by gender. The results in this study illustrate that mathematical modelling can be used to improve students' performance and is gender responsive enabling both boys and girls to increase their performance level in word problems based mathematics task. For this reason learners seem to exhibit the knowledge of mathematical modelling in learning mathematics.

Keywords: mathematical modelling, gender, performance, junior secondary schools mathematics

Introduction

One of the aims of the junior secondary school mathematics curriculum in Nigeria is to provide mathematical literacy to all students (FMoE, 2007). The 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 features through secondary mathematics (Ladele, 2013) [8].

To be successful in solving word problems, students need to learn how to read such problems and represent them algebraically in their second year in secondary school as they transit from arithmetic to algebra (Ladele, 2013) [8]. The process of matimizing or modelling of word problems is to ensure that students learn to know how to read between the lines and understand what they are expected to do mathematically (Barwell, 2011).

The Trends in International Mathematics and Science Study, report for the 2011 survey identified that algebra word problems generally presented the most difficult content for Grade 8 students (junior secondary 2 students) and that they only demonstrated a 37% facility in this area (TIMSS, 2012) [16]. Studies showed that this transition is difficult because of the students' level of background of the language of the text and the need to use variables, most often seen as letters, in arithmetical operations (Goldin, 2008) [7].

Yeo (2009) [20] opines that learners find it difficult to solve some related algebraic word problems as a result of their failure to comprehend the text language and as result leaners of mathematics becomes frustrated and tend to develop phobia in learning the subject. Understanding the structure of a word problem involves knowing how the mathematical information in a given word problem is related, and how to extract the components needed to solving the problem, these makes problem solver develop confidence and ability in solving related problems.

English, (2003) [4], Mousoulides, Sriraman, & Christou, (2007) [11] viewed that, students can only function effectively when they can comprehend and formulate an idea to solve related problems and for leaners to be good problem solvers, they must prepare and have the in-depth knowledge of the existing situation and this can only be possible when engage in modelling process (Lesh & Doerr, 2003).

Lesh *et al.*, (2007) [10] viewed modelling approach in a problem solving situation as an approach that concern with the explanation of the existing data and goals as major requirements that are needed in getting solution to the problem. The interpretation or explanations that are involve in the problem leads to the formation or development of an equation that can process data and students using the equation can operate and produce good solution to the problem (Kang *et al.* 2007). Figure 1 present modelling approach

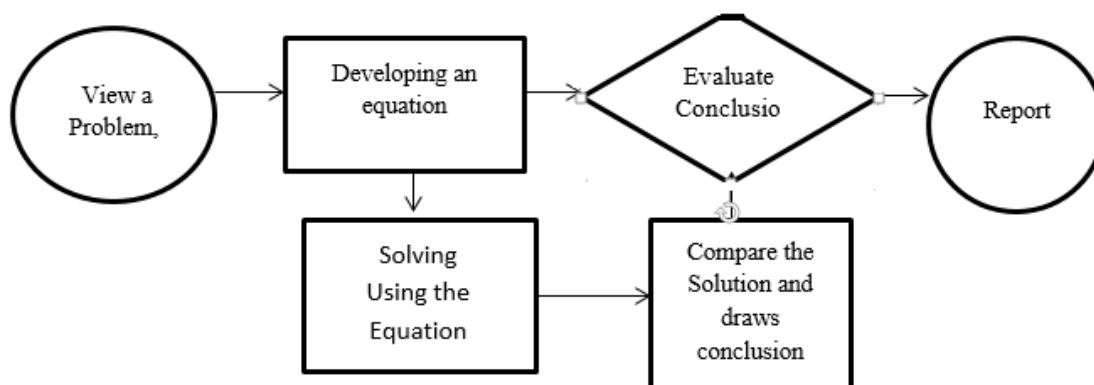


Fig 1: Mathematical Modelling Approach (Lesh *et al.*, (2007 & Kang *et al.* 2007) ^[10])

Figure 1 indicated various stages of mathematical modelling approach where both learners are expected view or analyse the problem situation, developed and formulate a model. Also learners were required to solve or compute solution of the model after which they interpret the solution and as well draws conclusion and report (Forsten, 2010)

In Nigeria, the review of junior secondary mathematics curriculum recommended that, mathematical modelling should be part of the learning strategy for all levels and defines it as “the process of formulating and improving a mathematical skill to represent and solve real-world problems” and that “students should learn to use a variety of representations of data, and to select and apply appropriate mathematical methods and tools in solving real-world problems” (FMoE, 2007: 14, JSMC, 2014). These new inclusions are by no means a minor extension to the curriculum.

Mathematical modelling therefore 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 well-designed and the suitable tasks for students is not known. 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 students misconceptions and mistakes in algebra problem-solving (Russell, O'Dwyer, & Miranda, 2009; Welder, 2012).

Olanipekun & Salman (2014) ^[12] in their study on effect of proficiency of the language of instruction toward competency in mathematics among Nigerian primary pupils sought to establish whether there was any significant difference in the academic performance of students in mathematics based on gender, the result indicated that the females gender tends outclass their male counter-parts in Mathematic.

Kaur & Gill (1993) revealed that when total performance was independent of sex, the boys scored higher than girls in Punjabi, Mathematics and Science. This therefore posits that gender difference in students' academic performance cannot be ignored since gender variation is now a significant factor t of performance in the subject.

Adeleke (2007) ^[1] in his study on gender disparity in mathematical performance found that no significant difference in performances exists between male and female students

when exposed to both Conceptual Learning Strategy (CLS) and Procedural Learning Strategy (PLS). Thus the study has revealed that students' performance in mathematics is not sensitive to gender. These differences are as a result of the relative effective of Conceptual and Procedural Learning Strategies of gender.

Studies on effect modelling on student performance by gender have yet to explore in Nigeria. Given the implementing issues of the concept in the syllabus, it is important to identify if this concept will support or be a constraint towards the states effort to reduce gender gaps in student performance especially in mathematics. This is the basic motivation of this article which shares findings from this study that focused on effect of modelling on student performance by gender at junior secondary level in mathematical problem solving.

Purpose of the Study

The purpose of this article is to share findings from a study of a mathematical approach based on gender performance among the junior secondary school students in mathematics by gender

Hypothesis of the Study

A null hypothesis was tested in this study at significance alpha level of 0.05.

H₀₁: There is no statistically significant difference in the effect of mathematical modelling regard to gender performance on word problem.

The Conceptual framework.

The conceptual frame work therefore was guided by the constructivism theory (Vygotsky, 1978, p. 56), specifically on social constructivism which links subjective and objective knowledge in a cycle in which each contributes to the renewal of the other. In this cycle, the path followed by new mathematical knowledge is from subjective knowledge (the personal creation of an individual), via publication to objective knowledge (by inter subjective scrutiny, reformulation, and acceptance). Objective knowledge is internalized and reconstructed by individuals, during the learning of mathematics, to become the individuals' subjective knowledge. Using this knowledge, individuals create and publish new mathematical knowledge, thereby completing the cycle. (Ernest, 1991, p. 43). The conceptual frame work for this research work is thus presented in figure 1 below. In the

frame work, the new strategy is the mathematical modelling approach which is independent variable, the intervening variable are teachers and the students and the dependant

variable is the learning outcomes based on gender. The interaction between these variables was the outcome of the study

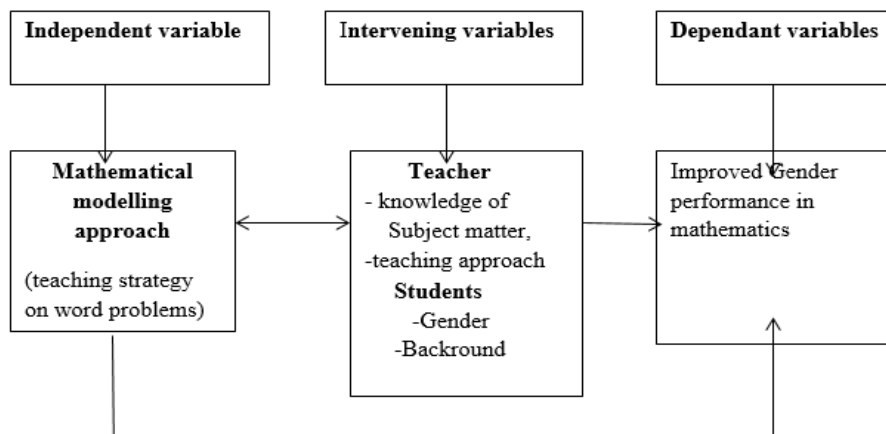


Fig 1: Conceptual framework (the researcher)

Methodology

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 ensure the effectiveness of the treatment on the variables, and allows whether the pre-test have effect on the subjects (Braver & Sanford 1988).

Solomon four group design involve two experimental groups (E1 and E2), and two control groups (C1 and C2). These groups were classified based on students’ gender. A pre-test and post-test was administered to both groups, but only the experimental group received treatment. The design for the experiment was in such a way that boys and girls in group E1 received pre-test (O1) with treatment X1 and post-test (O2). Boys and girls in group C1 received post-test (O3) with no treatment with post-test (O4). Also boys and girls in group E2 received no pre-test but with treatment (X2) and received post-test (O5). Likewise boys and girls in group C2 received no pre-test and no treatment but received post-test (O6). 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 figure below.

Table 1: Solomon Four Group Design

	Group	Pre-test	Treatment	Post-test
R	1	O1	X1	O2
R	2	O3		O4
R	3		X2	O5
R	4			O6

Source: Braver and Braver 1988.

Sampling Procedures

The sampling category was the junior public secondary

schools and not individual students since students operate as intact groups. The study used boarding secondary schools (junior level) to ensure that students involved in the study had academic abilities that were comparable. A list of boarding schools in Bauchi Southern educational zone used as a sampling frame. Purposive sampling technique was used to select four boarding schools (two boys and two girls’ schools) that formed the study sample. This sampling technique was considered to be important using two boarding schools for boys and two for girls so that will accommodate the gender issue. 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 JSS2 arms. The study being experimental 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 is presented in table 3 as follows:-

Table 2: Showing number of students in each group based on gender

Groups	E1	C1	E2	C2	Total
Boys	55	50	55	55	215
Girls	51	52	52	50	205
No. (N)	106	102	107	105	420

Source: (the researcher).

Instrumentation

Since the research focuses on effect of mathematical modelling on gender performance among junior secondary schools students, only one instrument was developed that tried to assess students’ achievement in mathematics (word problems). 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 modelling

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 Cronbach 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)

The review of junior secondary mathematics curriculum has recommended the inclusion of mathematical modelling as methods and tools in solving real-world problems" (FMoE, 2007 & JSMC, 2014). Only five (5) 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 week 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 2 present the modified mathematical modelling.

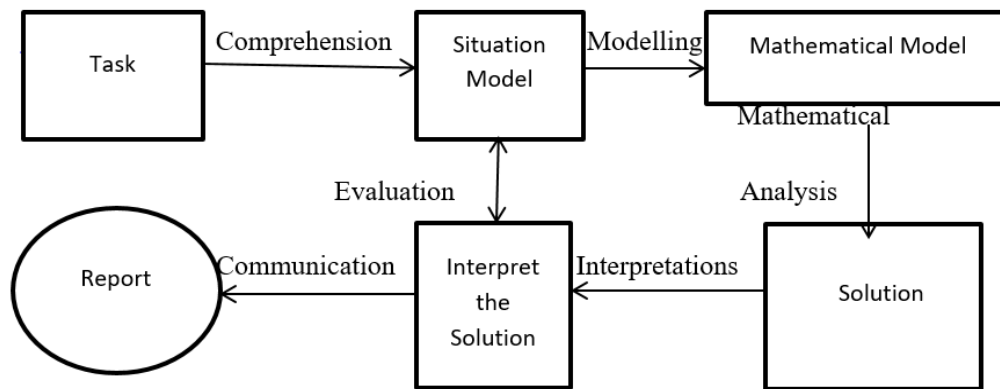


Fig 3: Modified Mathematical Modelling Approach (Researcher).

Modelling Approach (Researcher)

Figure 2 shows modified mathematical modelling procedures that were used by experimental teachers in the study. The use of procedures show 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 learners 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 shows how the lesson teachers guided learner on how to set the word problem into an equation form, using relevant operation to enable them solve the problem.
4. Interpretation process. Having obtained the solution, the learner make a careful observation to whether the solution make sense or not by representing real world situation and if not, the learner followed the same procedures until a correct solution was obtained
5. Emulation or Encoding process. The arrow shows the comparison of the obtained solution and the model situation. In case the solution has not represent the situation model, the learner again followed same procedures until an accurate solution is obtain and then report through communication process.

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, a student achievement test (MWPST) developed by the researcher 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) were tested. This was to examine and ensure there level of proficiency of the text language before the intervention.

After the intervention, the 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 students achievement test.

Data analysis

To assess the effect of mathematical modelling performance

among junior secondary schools students in mathematics by gender, the t-test independent sample statistics was used to determine whether there was no significance difference of the mean performance between male and female JSS2 students. This was computed and analysed using SPSS/PASW

Result

Effects of mathematical modelling among JSS 2 base on gender performance

To assess the effects of mathematical modelling on gender performance, result from the study were obtain from two tests (Pre-test and post-test) as it is required by the Solomon Four Group design. On the pre-test result, a comparison was made on the MWPST scores for boys and girls for group E1 and C1 schools. In this test, the two groups were combined based on gender and their means result is presented in table 3.

Table 3: Independent samples t-test of the pre-test mean scores on MWPST base on gender

Gender	N	Mean	SD	DF	T-value	P-value
Male	60	3.60	.45	108	13.16	.240
Female	50	3.40	.45			

Source: Field Survey, 2015

The results in table 3 indicates that the difference in MWST pre-test mean scores between male and female students were statistically insignificant, at $t(108) = 13.16$, $p > 0.05$ with male students having higher mean score than female students. This implies that students' performance in the test was similar and their level of understanding of word problem was also the same and that the groups used in the study exhibited similar characteristics. Thus, the hypothesis was then retained.

To test whether there were gender means differences in the effects of mathematical modelling in students' performance in word problems; a post-test was also administered to same categories of students, but only the experimental groups (E1 and E2) based on gender were considered. It was the only group that was exposed to the new strategy. Table 4 present the result.

Table 4: Independent samples t-test of the post-test mean scores on MWPST base on gender

Gender	N	Mean	SD	Df	T-value	P-value
Male	112	2.11	1.10	218	20.20	.000
Female	108	2.84	1.03			
Total						

Source: Field Survey, 2015

Results in table 4 indicated that, the difference in MWST post-test mean scores between male and female groups was statistically significant, $t(218) = 20.20 = 0.000$, $p < 0.05$. This implies that boys and girls who were taught using the Mathematical modelling approach show a significant increase in their performance. This hypothesis, which stated that, there was no statistically significant gender difference in performance in learning word problems using mathematical modelling teaching strategy, was rejected.

Discussion

Findings on students' performance on MWPST pre-test (table

4) revealed that there was insignificant difference on their understanding of word problems base on gender This shows that males and females students level of understanding word problems has not increased. By implication performance of students by gender varies as they were pre-tested prior to the learning strategy (modelling approach).

To determine the effect of mathematical modelling on gender performance in word problems, findings in table 4 post-test revealed a significant means difference on the effect of mathematical modelling on students' performance base on gender, The result indicated that, male and female students who learnt word problems through mathematical modelling strategy, performance increased significantly thereby reducing gabs or differences in their level of understanding. The finding agrees with Adeleke (2007) ^[1] which in his study on gender disparity in mathematical performance found that no significant difference in performances exists between male and female students when exposed to both Conceptual Learning Strategy (CLS) and Procedural Learning Strategy (PLS)

This findings is contrary to the findings of Olanipekun and Salman (2014) ^[12] who sought to establish whether there was any significant difference in the academic performance of students in Mathematics base on gender, the result indicated that the females have outclassed their male counter-parts in Mathematic. The findings of this study showed that students' performance based on gender was significant and the same. The mathematical modelling strategy therefore proved to be more effective in enhancing mathematics achievements for both male and female students than the conventional teaching methods.

The findings was also contrary to Yun (2001) who investigated gender differences in verbal (English language) and sciences (mathematical skills) among Chinese adolescent.. By implication, the mathematical modelling strategy proved to be more effective in enhancing mathematics achievements for both male and female students than the conventional teaching methods.

Conclusions

In conclusion, the results of this study proved that gender differences in learning mathematics among junior secondary school in Nigeria can be address significantly as students can learn through mathematical modelling. This is a clear indication that the strategy remains the best approach in learning algebra word problems among the Nigerian JSS2 students and beyond.

Implications of the study

The outcome of this study revealed that the mathematical modelling promotes active engagement and interaction of both males and females students in the mathematics classroom. Since the approach is effective at this stage of education, it is promising that the performance of Nigerian students in mathematics in examinations organized and coordinated by national and international bodies would be greatly improved. Further research may also be conducted to investigate the effectiveness of the intervention on the learning outcomes of Junior Secondary School students in mathematics in Nigeria.

Recommendations

The following recommendations are made based on the findings

1. Mathematics teachers at the junior school level should include mathematical approach as a based assessment tasks as part of their lessons.
2. Mathematics teachers should give all students equal opportunities in the classroom so that their confidence in the subject will be high.

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