ENHANCING SENIOR SECONDARY STUDENTS' COGNITIVE PERFORMANCE IN THE MATHEMATICS CONCEPT THROUGH PROBLEM SOLVING APPROACH

By

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Abstract

The study investigated the influence of Problem-Solving Approach on senior secondary school students' cognitive performance in mathematics concept with three statements of hypotheses formulated and tested.

A non-randomised Pre-test, Post-test and control groups quasi experimental (2x2) designed was adopted. A total of 205 (Male = 105 and Female = 100) students two in the public schools participated. A purposive sampling technique was employed to select two schools (one experimental and one control groups). Finally, an arm of intact class was selected. Two instruments (MCPT [r = 0.78] and TIP) were used for the study. The ANCOVA and MCA statistical tools were used.

The results show that there is a significant main effect of treatment on the Mathematics Cognitive Performance ($F_{(1,204)} = 65.303$; $P < 0.05$) and it also reveals shows that the experimental group (adjusted mean score of 36.358) is significantly better than the control group (adjusted mean score of 27.063) with respect to Mathematics Cognitive Performance. The treatment accounts for 23.23 percent $(0.482)^2$ x100% of the variation in the observed Mathematics Cognitive Performance. The results reveal that there is no significant main effect of gender on the Mathematics Cognitive Performance ($F_{(1,204)} = 0.471$; $P > 0.05$).

It is therefore recommended that educational stakeholders should endeavour to organise workshops to acquaint teachers of mathematics with how to use the Problem-Solving Approach in order to enhancing the quality of teaching mathematics in the classroom.

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Key words: *Problem Solving Approach, students' cognitive performance and gender*

Introduction

The lingering poor performance of students in most core subjects like Mathematics and English Language is no more news (Mutange, 2020; Alio, 2007). Some researchers such as Badru and Saka (2021); Arigbabu (2012) and Azuka (2012) had alerted the public on the poor standard of Mathematics of graduands from the primary, secondary and tertiary levels of Nigerian educational system. In the same vein, Mutange (2020) and Adepoju (2003) pointed out that deficiency in Mathematics is a major problem of the Nigerian educational system and called for improved teaching of the subject in schools. The call was necessitated on the importance of Mathematics in the society. Stressing the ugly situation, the reports of the West African Senior Secondary Certificate Examinations (WASSCE)

Chief Examiners (May/June, 2019 and 2020) indicated that candidates' performance had been on a steady decline. This same alarm had been sounded by some studies Badru and Saka (2021); Mutange (2020) and Adepoju (2003) reported that many students fear and dislike solving problems in Mathematics.

Despite the importance and relevance of Mathematics to the individual and the nation in general, it has raised the blood pressures of all stakeholders in education to all time high, it has not encouraged performance in mathematics particularly in WASSCE and National Examinations Council (NECO). The cause of students' poor performance in mathematics has not yet been fully identified in Nigeria even though different efforts have been made by researchers, educationist, government and nongovernmental organisation. It has been suggested that various instructional strategies that could improve students' performance in mathematics, for example, the National Mathematical Centre has provided a lot of teaching aids to improve the teaching and learning of mathematics in Nigeria. Also, non-governmental organisations have been organising mathematics competitions such as Cowbell Mathematics Competition in order to foster the interest of students in the subject. Meanwhile, results in such examinations are just reflections of long-term decay in the students' mathematical understanding and mastery of the subject (Arigbabu, 2012). The fact is that a lot of students have much difficulty with what is very simple and the art of problem solving was not properly developed in them. Also, Mathematics is a subject that trains the mind on attention and concentrations which are bound to be useful for the students throughout life and it also promotes the habit of accuracy, logical, systematic and orderly arrangements (Okafor & Anaduaka, 2015; Bala, 2006). Agwagah (2003); Azuka (2012); Bala (2006); Alio (2007) studied on the effect of quality of instruction on the performance of students in the learning tasks abound. The search for improvement in the instructional strategies that will enhance student's problem-solving ability and hence their performance level in mathematics has by no means abated. Therefore, this study tried to find the effects of using a problem-solving model on the students' ability to solve mathematics problems and thus enhance their cognitive performance level in the subject.

Mathematics thrives on problem solving, that is, inadequate or even lack of problem solving can greatly hamper mathematical growth of students (Arigbabu, 2012; Okereke, 2006). This probably explains why it is often said that problem solving is the pivot on which the axis of mathematics rotates. The art of problem-solving is the heart and essence of mathematics, because problem-solving can serve as a vehicle for learning new mathematical ideas and skills (Kousar, 2010). According to Zhu (2007) of assertion on the Mathematical Problem Solving (MPS) described it as several separate activities such as doing word problems, creating patterns, interpreting figures, developing geometric constructions and proving theorems and it is a complex cognitive activity. It can also be defined as a process that involved several dynamic activities: understanding the problem, making a plan, carrying out the plan and looking back. MPS is a teaching approach that is students-centred. It may improve and motivate students' learning, problem solving skills and broaden mathematics knowledge, based on deep understanding and problem solving. It can be defined as the ability to apply mathematical skills and concepts in different situation of life. In other words, it is when an individual can put his/her mathematics skills and concepts learnt over time to solve problems in real life situations, that person has applied MPS (Iji & Uka, 2012; Fadaka, 2004). According to Okafor and Anaduaka (2015) and Alio (2007), the primary goal of mathematics teaching and learning is to develop the ability to solve a wide variety of complex problems which include mathematical and problems in other field of endeavour if such problems can be put in mathematical forms. Arigbabu (2012) on why problem solving should be taught in school gave the following reasons:

i. problem solving is a major part of mathematics. It is the sum and substance of our discipline and to reduce the discipline to a set of exercises and skills devoid of problem solving is misrepresenting mathematics as a discipline and shortchanging the students.

ii. mathematics has many applications and often those applications represent important problems in mathematics.

iii. there is an intrinsic motivation embedded in solving mathematics problems. Hence, it has been included that problem solving in school mathematics can be stimulating the interest and enthusiasm of the students.

iv. problem solving must be in the school mathematics curriculum to allow students to develop the art of problem solving.

However, students' gender plays a paramount role on problem solving approach in learning mathematics at secondary schools. Studies of Okereke (2006) found that males generally outperformed females on mathematical tasks; Zhu (2007) showed different sizes of gender differences with respect to types of mathematical tasks and concluded that the situation of gender differences in mathematical problem solving is very complex and Fadaka (2004) reported that there was very small or null gender difference in mathematics performance on these tests. Zhu (2007) and Caplan and Caplan (2005) even confirmed that the link between gender and the mathematics performance was very weak.

This study adapted Arigbabu (2012) method of strategy the following first four phases of problem solving:

Step 1: Analysis of the problem: Read and re-read the problem until it is well understood

Step 2: Identification of basic or relevant facts: List the given values, identify the required values, draw diagrams, define related terms and related the problem to similar ones earlier solved.

Step 3: Identification of appropriate strategy: Identify the required formulae for the solution of the problem and identify the various intermediate results necessary.

Step 4: Using the strategy adopted: Employ the formulae identified in Step 3 to solve. The Problem-Solving Approach is illustrated in the Figure 1 below.

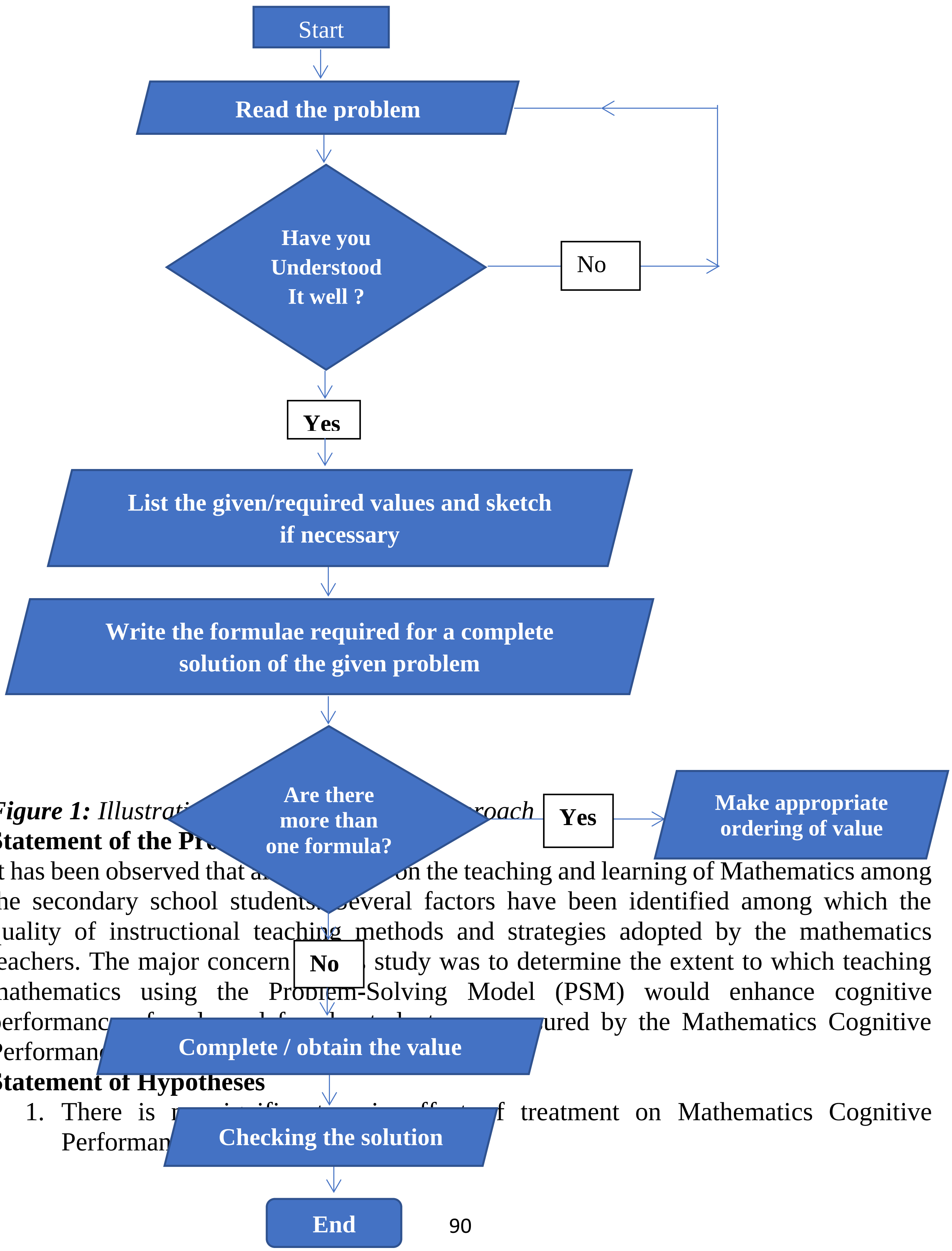

***Figure 1:** Illustrati* … *roach*

Statement of the Pr …

It has been observed that a … on the teaching and learning of Mathematics among the secondary school students. … everal factors have been identified among which the quality of instructional teachin… methods and strategies adopted by the mathematics teachers. The major concern … study was to determine the extent to which teaching mathematics using the Pro…m-Solving Model (PSM) would enhance cognitive performanc… …ured by the Mathematics Cognitive Performan…

Statement of Hypotheses

1. There is … f treatment on Mathematics Cognitive Performan…

2. There is no significant main effect of students' gender on Mathematics Cognitive Performance.
3. There is no significant interaction effect of treatment and students' gender on Mathematics Cognitive Performance.

Methods

a. **Research Design**: This study adopted a non-randomised Pre-test, Post-test and control groups quasi experimental design. The factorial design adopted for this study is 2x2 designed. Students from one school were designated the Experimental group A while those from the other school were designated the Control group B. the two schools were located quite far from each other to eliminate a possible interference of the treatment given to A but denied B. both groups were given MCPT which contained problems on mensuration and set.

b. **The variables of the study**
   i. Independent variable is Treatment at the two levels (Problem Solving Model – Experimental group and Teacher's guided – Control group)
   ii. Moderating variable is gender of the students at the two levels (Male and Female)
   iii. Dependent variable is Cognitive performance in mathematics

c. **Sample and Sampling techniques**
   A total of 205 Senior Secondary Students (SSS) 2 in the public schools took part in this study. A purposive sampling technique was employed to select two schools (one experimental and one control groups). The eligible schools that participated in this study must have a qualified and experienced mathematics teacher that was willing to assistant the students. The schools must also have been registering students for WASSCE for past at least five years. The students must be in science class. Finally, an arm of intact class was selected that is, the use of intact classes in research undertakings as they do not disturb the naturalness of the school setting.

d. **Instrumentation**
   Two instruments were used for the study:
   i. **Mathematics Cognitive Performance Test (MCPT):** A 30 – item multiple choices Mathematics Cognitive Performance Test (MCPT) on mensuration and set, designed by the researcher. When tested on a sample of twenty-five subjects, it gave a reliability index (K-R 20) of 0.78.
   ii. **Treatment Instructional Packages (TIP):** The TIP represents the model lesson Plan for the experimental and control groups. The mathematics teachers of the classes were employed for the research assistants for the study. They were instructed and guided on the use of the TIP and to ensure that the right kind of environment was maintained for experimental and control groups. The two groups were given the MCPT to the students as a pre-test in order to be sure that they all have the same entry for the topics chosen after granted permission from the school's authority concerned. This was done in the first week of the treatment

period. The following steps guided the treatment in both the experimental and control groups:

A. Experimental group: The group was exposed to Solving Problem Instructional Package (SPIP) for four weeks at the rate of two periods per week. The model adopted six stages as follows:

Step 1: students read and re-read the problem until it is well understood. That is, a triangle has sides of length x cm, (2x-1) cm, and (2x+1) cm, if its perimeter is 40cm. find the length of the sides of the triangle (Macrae, et el, 2011).

Step 2: identification of basic or relevant facts.

That is, given that:

L_1 = x cm, L_2 = (2x-1) cm and L_3 = (2x+1) cm

Perimeter P = 40 cm

Required to find: The length of the sides of the triangle (L_1, L_2 & L_3)

Step 3: Applying the appropriate formula

$P = L_1 + L_2 + L_3$

Step 4: Obtain the values of:

By substituting for the values

40	=	x + 2x -1 + 2x+1		
5x	=	40		
x	=	8cm		
L_1	=	x		= 8 cm
L_2	=	2x-1	= 2x8 – 1	= 15 cm
L_3	=	2x+1	= 2x8+1	=17 cm

Step 5: Checking for the solution

P	=	L_1	+	L_2	+	L_3
40	=	8	+	15	+	16
40	=	40				

Step 6: Conclusion/Answer. The results of the length of the sides of the triangle are 8cm, 15cm and 17cm.

Each step of the model was carefully explained while students were guided to overcome their difficulties. Experimental group involved many practices on the use of the model.

B. Control group: The teachers presented lessons as usual without any instructions or guidelines from the researcher.

The groups were treated for four weeks. After the treatments (5^{th} week), all the subjects were given the same MCPT as a post test.

Data Analysis procedures

The procedure for data analysis involved the use of descriptive and inferential statistics (Analysis of Covariance and Multiple Classification Analysis).

Results and Discussion

Table 1: Analysis of Covariance (ANCOVA) of Post-test mean scores by treatment and Gender of MCP.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6415.836[a]	4	1603.959	25.418	.000	.337
Intercept	10530.294	1	10530.294	166.876	.000	.455
Pr	1826.938	1	1826.938	28.952	.000	.126
Tre	4120.749	1	4120.749	65.303	.000	.246
Sex	29.719	1	29.719	.471	.493	.002
Tre * Sex	68.587	1	68.587	1.087	.298	.005
Error	12620.476	200	63.102			
Total	219216.000	205				
Corrected Total	19036.312	204				

Table 2: Multiple Classification Analysis (MCA) of MCP according to treatment and Gender

Grand mean = 31.461

			N	Predicted Mean		Deviation		Eta	Beta
				Unadjusted	Adjusted for Factors	Unadjusted	Adjusted for Factors		Adjusted for Factors
post test	treatment	Solving problem	97	36.1340	36.1457	4.88524	4.89693	.480	.482
		control	108	26.8611	26.8506	-4.38767	-4.39817		
	Gender	male	105	31.4286	31.5776	.17979	.32877		
		female	100	31.0600	30.9036	-.18878	-.34521	.019	.035

Hypothesis 1: There is no significant main effect of treatment on Mathematics Cognitive Performance.

To test for Hypothesis 1 in respect of the main effects of Treatment on Mathematics Cognitive, the results of the Analysis of covariance (ANCOVA) as presented in Table 1 was used. The result in Table 1 revealed a significant outcome in respect of the main effect treatment on Mathematics Cognitive ($F_{(1,204)} = 65.303$; $P < 0.05$). This implies that there is a significant main effect of treatment on the Mathematics Cognitive Performance. In order to determine the magnitude of the mean Mathematics Cognitive Performance scores of students exposed to the treatment conditions, the results of the Multiple Classification

Analysis (MCA) presented in Table 2 was used. The results revealed that with a grand mean of 31.461, the experimental group (Solving problem Approach) had an adjusted mean score of 36.358 (31.461+4.897) while the control group (TGM) had an adjusted mean score of 27.063 (31.461 – 4.398). This shows that the experimental group is significantly better than the control group with respect to Mathematics Cognitive Performance. The table also presents a value of Beta for the treatment as 0.482 which implies that the treatment accounts for 23.23 percent $(0.482)^2$ x100% of the variation in the observed Mathematics Cognitive Performance. Hence, it shows that the treatment is significantly affecting the Mathematics Cognitive Performance. The studies of Mutange (2020) and Okafor and Anaduaka (2015) confirmed that Problem Solving Approach is a more effective teaching approach to the students in the County schools in comparison to those in the National and Sub- County schools. In a related study, Nekang (2013) who reported from his findings that students exposed to the Rusbult's Problem Solving Strategy (RUPSS) achieved higher than those exposed to CPSS. Similarly, Kousar (2010) and Major, Baden and Mackinnon (2000) reported that there was significant difference between the effectiveness of traditional teaching method and problem solving method in teaching of mathematics at elementary level. In addition, Azuka (2012) asserted that the treatment improves the quality of instruction with regards to the teaching of Mathematics for optimal gain in secondary schools in Nigeria major differences in the effects of the various treatments in helping students to learn to the mastery criterion of two grades. In a contrary view, Iroegbu (2012) reported that there is no statistically significant difference in achievement of pupils exposed to the different reading strategies. Okereke (2006) also asserted that no strategy can be called the best for teaching mathematics at secondary school level. Nevertheless, the knowledge of strategies will place in a better position to manipulate them to achieve maximum performance in the students' learning behaviour. It should be noticed that whatever strategy a teacher uses, his/her aim it to achieve a desired outcome (no matter how little) in students.

Hypothesis 2: There is no significant main effect of students' gender on Mathematics Cognitive Performance.

To test for Hypothesis 2 in respect of the main effects of Gender on Mathematics Cognitive, the results of the Analysis of covariance (ANCOVA) as presented in Table 1 was used. The result in Table 1 revealed no significant outcome in respect of the main effect gender on Mathematics Cognitive ($F_{(1,204)} = 0.471$; $P > 0.05$). This implies that there is no significant main effect of gender on the Mathematics Cognitive Performance. In order to determine the magnitude of the mean Mathematics Cognitive Performance scores of students exposed to the gender conditions, the results of the Multiple Classification Analysis (MCA) presented in Table 2 was used. The results revealed that with a grand mean of 31.461, the male students had an adjusted mean score of 31.790 (31.461+0.329) while the female students had an adjusted mean score of 31.016 (31.461 – 0.345). This shows that the male students are slightly better than the female students with respect to Mathematics Cognitive Performance. The table also presents a value of Beta for the treatment as 0.035 which implies that the gender accounts for 0.1225 percent $(0.035)^2$

x100% of the variation in the observed Mathematics Cognitive Performance. Hence, it shows that the gender of the students is not significantly affecting the Mathematics Cognitive Performance. That is, the students' gender has no effect on the students' Cognitive Performance in the Mathematics Concept.

Hypothesis 3: There is no significant interaction effect of treatment and students' gender on Mathematics Cognitive Performance.

To test for Hypothesis 3 in respect of the interaction effect of treatment and students' gender on Mathematics Cognitive, the results of the Analysis of covariance (ANCOVA) as presented in Table 1 was used. The result in Table 1 revealed no significant outcome in respect of the interaction effect of treatment and students' gender on Mathematics Cognitive ($F_{(1,204)} = 1.087$; $P > 0.05$). This implies that there is no significant interaction effect of treatment and students' gender on the Mathematics Cognitive Performance.

Recommendations

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

1. Teachers of mathematics are encouraged to use this SPIP in teaching their students how to solve mathematical problems. They should observe their students in class situations as they solve problems and make sure that the students use the SPIP in problem solving.
2. Educational stakeholders such as Mathematics educators, Federal and State Ministries of Education and Teaching service commissions should endevour to organise workshops to acquaint teachers of mathematics with how to use the SPIP in order to enhancing the quality of teaching mathematics in the classroom.
3. Lastly, Mathematics textbook authors and publishers should be encouraged to incorporate the steps of this SPIP in their solved examples in order to offer teachers of mathematics and students the opportunity of using the approach even unguided. Because present textbooks used in the schools are traditional. The traditional textbooks do not meet the criteria of problem solving approach.

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