EFFECT OF STYER PROBLEM SOLVING INSTRUCTIONAL STRATEGY ON STUDENTS' MATHEMATICAL SKILLS IN ADAMAWA STATE, NIGERIA

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Abstract

The study determined the effect of Styer problem solving instructional strategy on senior secondary school students' mathematical skills in Mubi education zone of Adamawa state. Two purposes, two research questions and two hypotheses were formulated. The study adopted a non-randomized, non-equivalent quasi experimental design where intact classes were used. The population for the study comprised of 7697 SS II students in Mubi education zone, while sample of the study was143 students with 73 students for the experimental group and 70 students for the control group. The sample comprised 90 males and 53 females. The sample was selected using purposive and simple random sampling techniques. The instrument used for data collection was adapted from Mathematical Skill Test (MST) with 30 items. The instrument was validated by three experts in mathematics, mathematics education and measurement and evaluation. The instrument was trial tested using 30 students and was subjected to Kuder-Richardson 20 for the reliability. The reliability coefficient obtained was 0.78. The experiment lasted for a period of eight weeks. Data collected was analyzed using descriptive statistics (mean and standard deviation) in answering research questions, while the hypotheses were tested using ANCOVA (Analysis of Covariance) Results show that experimental group has higher mean score of 50.05 than control group with mean score of 35.03 in the post test. Similarly, there is significant effect of treatment on students' mathematical skills ($F = 20.16$, $df = (1, 142)$; $p = 0.00$). Also, finding indicate there was no significant effect (the method used) on students' mathematical skills based on gender ($F = 2.00$, $df = (1, 142)$; $p = 0.215$). Based on the result, it was recommended that teachers at senior secondary schools should adopt Styer problem solving instructional strategies in teaching mathematics as it increases students' mathematical skills and balances between male and female mathematical skills.

Key Words. Styer problem solving, Instructional Strategy, Mathematical skills and Gender

Introduction

Mathematics is a subject that cut across other discipline such as engineering, medicine, education, social sciences among others. This is because of the application of its skills in such areas. Mathematical skills are important in developing learner reasoning abilities for problem solving in different way, less time consuming and short forms (Bambang, Nugroho & Muzayanah, 2020). Therefore, mathematical skills are necessary and relevant skills in solving any problem by providing the problem solver with guide on steps required to solve a given problem. However, students have different mathematical skills and it can tax their ability differently. In problem solving, the procedure

involves in solving any problem is outline, but the difficulty that the problem solver may encounter is to do the calculation correctly. In some problems, it is very difficult for students to work out what kind of calculation they need to do in solving the problem, even when the calculation itself is an easy one. To solve this type of problems, the students has to begin by reasoning about the quantities involved which is called mathematical skills, the students establishes relations between different quantities of problem or between different states of the same quantity of problem over time (Nunes, Bryant, Evans, Gottardis & Terlektsi, 2015). Mathematical skills can be viewed as a means of mobilizing the cognitive and practical skills, creative abilities and other psychological resources such as attitude, motivation and values that facilitate individual thinking ability (Program for International Students' Assessment: PISA, 2012). It can also be described as a gauge of an individual critical thinking. According to International Baccalaureate Organization (IBO, 2012), mathematical skills requires a critical thinking that involves a complex mental process such as paying attention to details, selecting relevant information, analyzing carefully, making judgments and meta-cognitive thinking such as reflection and higher-order plans. It is an essential skill for both academic achievement and for dealing with various real-life problems.

Mathematical skills as reasoning abilities emphasized in a variety of content areas of curriculum planning documents across cultures. Students' mathematical skills demonstrate their capacity to think critically, communicate clearly, and solve complex mathematical problems and applied knowledge in real-world settings (Su, Ricci & Mnatsakanian, 2016). Okoronka (2020) consider mathematical skills as the basic abilities required to performs certain tasks or skills that are required for survival by all, like skills for working in group, communicating clearly, understanding technology and using mathematical concepts. To develops or enhance these skills, students need to master varied problem solving instructional strategies. However, students' mathematical skills have been poor due to their inability to employ or use different strategies in solving mathematics problems and understand that one problem can be solved using different strategy (Nurullita, Edy, & Edi, 2017). Similarly, Szabo (2017) noted that students dislike to mathematics is basically attributed to their inability to reason and think mathematically, as doing mathematics involves higher order skills that may be developed through problem solving strategies of different stages (Polya four, Styer three, rational decision making five). This resulted in low and inefficient students' mathematical skill for problem solving which can be remediated by application of suitable and varied problem solving instructional strategies. Similarly, it is common that male and female skills in mathematics varies based on their ability. Female students tend to be more disturbed and take more time while solving mathematical problems which may due to lack of appropriate skills. Muhammad and Winda (2019) reveals that male students are more composed and organized while solving problems than their female counterparts which could be attributed their high level of mathematical skills.

Styer (2002) described the three stages of problem solving strategy as outlined based on what the problem solver is expected to undergo in each of the steps as follows: strategy design where the problem solver is expected to classify the problem by its method of solution,

summarize the situation with a diagram and keep the goal in sight (perhaps by writing it down), strategy Execution/ tactics involves working with symbols, keep packets of related variables together, be neat and organized and keeping it simple and answer checking include making sure that it is dimensionally consistent, numerically reasonable (including sign), algebraically possible (Example: no imaginary or infinite answers), functionally reasonable (Example: greater range with greater initial speed.), check special cases and symmetry .

Problem solving instructional strategies according to Moursund (2016) involves moving from a given initial situation to a desired goal situation. That is, problem solving is the process of designing and carrying out a set of steps to reach a goal. Usually the term problem is used to refer to a situation where it is not immediately obvious how to reach the goal. The situation can be a problem for one person and not a problem (perhaps just a simple activity or routine exercise) for another person. Bambang, Nugroho and Muzayanah, (2020) regard problem solving instructional strategy as means of improving a range of skill like analyzing, interpreting, reasoning, evaluating and reflecting which enable learners solve mathematical problems. Problem solving is therefore a principal component of mathematical skills for building reasoning abilities for self-sufficient science. Problem solving is a special kind of learning outcome quite unlike other learning outcomes because it makes use of an outline steps or stages that problem solver should follow in solving any given problem. Moreover, there are many different kinds of problem solving instructional strategies, and each requires different forms of teaching and learning support.

Su, Ricci and Mnatsakanian (2016) in their study on mathematical problem solving teaching strategies as pathways to mathematical thinking and meta-cognition noted that teaching problem solving to students can develop their ability when confronting mathematical problems, identify possible solutions, evaluate and justify their reasons for the results, thereby allowing students to become confident mathematical thinkers by developing their problem solving skills. Critical thinking and reasoning allow students to think about how they utilize their discipline of mathematical skills (that is they think about their method of thinking), help students to recognize that mathematics is logical reasoning on solutions to problems and students are taught how to identify scenarios, evaluate and identify possible conclusions through problem-solving strategies (Raoano, 2016). Muhammad and Winda (2019) conducted a study on the use of Polya's strategy to determine mathematical problem solving ability of junior high school students in Banjarmasin, Indonesia.

Results indicated students' high skills in using Polya's steps. Implies that the ability to understand the problem, ability to plan and ability to execute the plan. Saygılı (2017) examined the mathematical skills and the strategies used by high school students in solving Non-routine problems. Results on students' solutions showed that each student employed at least three problem solving strategies. Nine out of the ten possible problem solving strategies were used at least ones to solve the eight non-routine problems. The most frequently used strategies were making systematic list, looking for patterns, logical reasoning and making a model or diagram. Those who were proficient in the use of

solution strategies also performed well. However, most strategies used were of four, five or more stages which may take more time to get to the solution of the problem, but Styer has shorten the stages to three and it may require less time which mathematical skills is advocating. That is, the faster you solve the problem, the better your skills of mathematics. Therefore, the study sought to know if the use of three stages problem solving instructional strategy could improve students' mathematical skills.

Statement of the Problem

Everyone has skills in solving a problem and the skills differs from one person to another depending on their ability, persistence and gender of the individual. It is common that female tend to show more worries when encountered with problem compared to their male counterparts and it affect how we approach problem solving. This make mathematics as a male dominated subject because it involves solving problems or finding the unknown. Sometime we can solve problem without difficulties by using a strategy that worked in the past. Problems become more complex when there are no strategies that one has tried in the past did not solve the problem. Such problems cause stress and anxiety that may require new and different strategies. In a situation where one could not get new strategy, it leads to frustration, set back and even increases the problem. This is similar with students solving mathematics problems which have consequently affected their mathematical skills at different levels, particularly in Nigeria and Adamawa state, where the number of students obtaining credit pass is always less than 50% of the number of students registered both nationwide and state wide which could be attributed to their low mathematical skills. Similarly, when it comes to gender, female students perform poorer than male students in mathematics due to their low skills in reasoning out a situation or problem. This will lead to setback toward the overall development of the nation as science and mathematics is the basis for technological development. Students' poor performance is attributed to poor problem solving strategies adopted by problem solvers and students. Therefore, good and appropriate instructional strategies may provide alternative means of handling such problems successfully. Mathematics problems solving instructional strategies may be capable of balancing both male and female students' mathematical skills and overcoming their difficulties in solving mathematics problems. The mathematical skills may become better and improved when the strategy applied is short and concise. Therefore, the study determines the effect of Styer problem solving instructional strategy on senior secondary school students' mathematical skills.

Purpose of the Study

The purpose of the study was to determine the effect of Styer problem solving instructional strategy on mathematical skills of senior secondary school students in Mubi education zone of Adamawa state. Specifically, the study determined:

1. the effect of Styer problem solving instructional strategy on mathematical skills of senior secondary school students.
2. the effect Styer problem solving instructional strategy on mathematical skills of male and female students in senior secondary school.

Research Questions

In line with the purposes of the study, two research questions were raised to guide the study as follows:

1. what is the mean score difference in students' mathematical skills when taught using Styer problem solving instructional strategy and conventional strategy?
2. what is the mean score difference between male and female students' mathematical skills when taught using Styer problem solving instructional strategy?

Hypotheses

The following null hypotheses were raised and tested at 0.05 level of significance

H_{O1}: There is no statistically significant difference between the mathematical skills of students taught using Styer problem solving instructional strategy and those taught with the conventional strategy.

H_{O1}: There is no statistically significant difference between the mathematical skills of male and female students taught using Styer problem solving instructional strategy.

Methodology

The study employed the quasi experimental design, specifically the non-randomized, non-equivalent, pre-test, post-test, control group. The population of the study was 7697 SS II students in Mubi education zone, Adamawa state. The sample for the study consisted of 143 students, where 73 students for the experimental group and 70 students for the control group comprising 90 males and 53 females selected using purposive and simple random sampling techniques in two boarding schools in Mubi. Purposive was used in selection of boarding and coeducation schools, while simple random was in selection of a class from the stream of SS II and assigning the classes into experimental and control group.

The instrument used for data collection is namely: Mathematical Skill Test (MST) adapted from Butt (2004). The test consisted of 30 items short answers, fill in the blank space and multiple-choice questions that determined students reasoning skills in solving problems which was modified to 30 objective items with five options A to E multiple-choice questions. The questions comprised of knowledge, comprehension, application and analysis with application and analysis covering the highest aspect of the cognitive domain. This is because students are expected to use their skills to solve the problems by applying relevant skills at each step while solving the problems. The items were scored one mark for correct answer and zero for wrong answer with a total score of 30 marks that was converted to 100 percent for analysis.

The instrument was given to three experts in mathematics, mathematics education and measurement and evaluation for validation from Modibbo Adama University, Yola; Adamawa State University, Mubi and Gombe State University respectively. They all suggest that the pattern of the answer should be similar. Meaning that it should either be all short answers or fill in the blank space or multiple choice. Based on their suggestion, it was converted to multiple choice with five options. A final copy was produced for the experiment. It was administered to 35 SSS III students for trial test and scores were subjected to Kuder-Richardson 20 for reliability nd an index value of 0.78 was realized.

A pre-test of Mathematical Skill Test (MST) was administered by the research assistants to both the experimental group and control groups in their respective classes and their scores recorded. Experimental group was taught using Styer Problem Solving Instructional Strategy. The experimental group was introduced to the problem solving instructional strategy used before the instruction and the problem solving instructional strategy was followed strictly. That is students should be guided in strategy design where the problem solver is expected to classify the problem by its method of solution, summarize the situation with a diagram and keep the goal in sight (perhaps by writing it down), strategy Execution/ tactics involves working with symbols, keep packets of related variables together, be neat and organized and keeping it simple and answer checking include making sure that it is dimensionally consistent, numerically reasonable (including sign), algebraically possible (Example: no imaginary or infinite answers), functionally reasonable (Example: greater range with greater initial speed.), check special cases and symmetry (Styer, 2002).

In conducting the experiment, two research assistants were employed and trained for one week by introducing them on the use of Styer strategy and the conventional method on the basis that they have B. Sc (Ed) or B. Tech (Ed) Mathematics qualification and teaching experiences of at least five years to enable them be familiar with practical skills in teaching. Each of the research assistants handled an intact class during the experiment. Each research assistant was oriented and was provided with lesson plan and teacher guide for implementation and the experiment lasted for eight weeks. After the experiment, a post test was administered and scored to be analyzed together with the pretest using ANCOVA.

Results

Research Question One

what is the mean score difference in students' mathematical skills when taught using Styer problem solving instructional strategy and conventional strategy?

Table 1: Descriptive Statistics of Mean and Standard Deviation for the Analysis of Students' Mathematical Skills based on Treatments

Groups	Pre-test n	$\overline{X}$	SD	Post-test $\overline{X}$	SD	MD
Styer	73	22.90	8.64	50.05	18.04	27.15
Control	70	21.10	8.15	35.03	8.19	13.93
Overall Mean Difference						15.02

Table 1 result display the mean and standard deviation for the pretest and posttest of the experimental and control groups, where 73 students in Styer group with pretest mean scores of 22.90 and standard deviation of 8.64. While posttest mean score of 50.05 and standard deviation of 18.04 was obtained. This give a mean score difference of 27.15. The overall mean difference between the experimental and control groups in the post test was 15.02 which indicate that the experimental group perform higher than the control group.

Research Question Two

what is the mean score difference between male and female students' mathematical skills when taught using Styer problem solving instructional strategy?

Table 2: Descriptive Statistics of Mean and Standard Deviation for the Analysis of Male and Female Students' Mathematical Skills based on Treatments

Gender	n	$\bar{X}$	SD	Mean Difference
Male	90	41.28	15.82	3.83
Female	53	45.11	16.03	

Table 2 show the mean and standard deviation analyses on the effects of gender on treatment (male and female students' mathematical skills for the Styer strategy). Male students had a mean score of 41.28; standard deviation of 15. 82, while female students had a mean score of 45.11; standard deviation of 16.03. This gives a mean difference of 3.83 in favour of female students.

Hypothesis One

There is no statistically significant difference between the mathematical skills of students taught using Styer problem solving instructional strategy and those taught with the conventional method.

Table 3: ANCOVA for the Treatment on Students' Mathematical Skills in Mathematics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	8077.75[a]	2	4038.88	20.16	.000
Intercept	34287.19	1	34287.19	171.14	.000
PRETEST	9.41	1	9.41	0.47	.829
TEACHING METHOD	**7463.87**	**1**	**7463.87**	**37.26**	**.000***
Error	28048.32	140	200.35		
Total	296848.00	143			
Corrected Total	36126.07	142			

Table 3 show that there is significant effect of treatment on students' mathematical skills in mathematics (F = 20.16; df = (1, 142); p = 0.00). Therefore, there is statistically significant difference between the mathematical skills of students taught using Styer problem solving instructional strategy and those taught with the conventional method.

Hypothesis Two

There is no statistically significant difference between the mathematical skills of male and female students taught using Styer problem solving instructional strategy.

Table 4: ANCOVA for the Treatment on Male and Female Students' Mathematical Skills in Mathematics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1003.81[a]	2	501.91	2.00	.139
Intercept	29257.54	1	29257.54	116.62	.000
PRETEST	513.12	1	513.12	2.05	.155
GENDER	389.93	1	389.93	1.55	.215
Error	35122.26	140	250.87		
Total	296848.00	143			
Corrected Total	36126.07	142			

Result in Table 4 indicates that there is no significant effect of treatment on male and female students' mathematical skills in mathematics (F = 2.00; df = (1, 142); p = 0.215) as the computed p-value (0.215) is higher than 0.05 level of significance. Therefore, the null hypothesis that there is no significant effect of treatment on male and female mathematical skills in mathematics not rejected. This means that there is no statistically significant difference between the mathematical skills of male and female students taught using Styer problem solving instructional strategy.

Discussion of Results

The results of this study revealed that there was high mean score difference between the pretest and the posttest of students' mathematical skills based on the treatment with styer strategy having higher mean (50.05) than control (35.03). The finding further showed that there was a significant effect of treatment on students' mathematical skills when taught using styer problem solving instructional strategy in Mubi education zone of Adamawa state (F = 20.16; df = (1, 142); p = 0.00). This implies that students taught using styer problem solving instructional strategies performed higher than those taught with the conventional lecture strategy of teaching because there was no significant difference in their pretest mean scores. This finding is in agreement with the findings of Saygılı (2017) who examined the mathematical skills and the strategies used by high school students in solving Non-routine problems. Finding revealed significant difference between the experimental and control groups. It is also similar to the finding of Muhammad and Winda (2019) who conducted a study on the use of Polya's

strategy to determine mathematical problem solving ability of junior high school students in Banjarmasin, Indonesia. Results indicated students' high skills in using Polya's steps. That is ability to understand the problem, ability to plan and ability to execute the plan. The result of the study also agrees with that of Su, Ricci and Mnatsakanian (2016) in their study on mathematical problem solving teaching strategies as pathways to mathematical thinking and meta-cognition that realize teaching problem solving to students can develop their ability in mathematical skills by identifying possible solutions through evaluating and justifying their reasons for the results.

The finding from the study on the effect of gender on Styer problem solving instructional strategy on mathematical skills of senior secondary school students showed that mathematical skills of males students with mean of 41.28 and females students with mean of 45.11 did not differs significantly based on the treatment ($F = 2.00$; $df = (1, 142)$; $p = 0.215$). The finding is in agreement with the finding of Nurullita, Edy, and Edi (2017) on the effect of problem solving based learning to students' mathematical problem solving ability that indicates that mathematical problem solving skills of secondary school students did not significantly differ. The findings of the study align with some studies as indicated as both studies use problem solving instructional strategies in measuring students' mathematical skills on mathematics. It also disagrees with some studies as different problem solving strategies were used in measuring students' mathematical skills in mathematics. Some strategies use five steps, four steps, while this study use three steps strategy which implies that this finding of Styer three strategy problem solving improves students' mathematical skills for solving mathematics.

Conclusion

Styer problem solving instructional strategy is an effective means of improving mathematical skills of students in senior secondary school and it is also effective in balancing the mathematical skills of both male and female students. Therefore, it should be employed by teachers as to overcome poor mathematical skills of students and enhances their academic performances in mathematics.

References

Bambang, S. W., Nugroho, H. P. & Muzayanah, D. (2020). Analysis of problem solving skill of demographic dynamic in light of gender perspective among students of different cognitive styles. *Journal of Advance in social Science, Education and Humanities Research*, 473, 248 – 251.

Butts, T. (2004). *Teaching mathematics through problem solving*: A personal perspective. Retrieved from http://www.problemsolvingskilltbutts/utdallas/edu.

International Baccalaureate Organization (IB O, 2012). *Approaches to learning:* Lit erature Review. Retrieved on 14th July 2020 from www.IB.AL:LR

Moursund, D. (2016). *Learning problem solving strategies by using games: A guide for educators and parents.* Information Age Education, Eugene, Oregon, USA.

Muhammad, R. & Winda, A. (2019). Junior high school students ability to use the

Polya's step to solve mathematical problems through problem based learning. *International Journal of Trends in Mathematics Education Research, 2*(1), 86-90.

Nunes, T., Bryant, P., Evans, D., Gottardis, L.& Terlektsi, M. E. (2015). *Teaching mathematical problem solving skills Probability and problem solving inthe classroom.* Nuffield Foundation, University of Oxford.

Nurullita, A., Edy, S. & Edi, S. (2017). The effect of problem solving based learning to students mathematical problem solving ability. *International Journal of Advance Research and Innovative Ideas in Education,* 3 (2), 3441 – 3446.

Okoronka, A. U. (2020). *Teaching the strategies to support students' acquisition of problem solving skills in Physics.* In C. N. Alimba; K. T. George; K. M. Badau; Z. F. Kigundu & M. O. Ararumi (eds.). *Critical issues in education: A Festschrift.* School of Education and legal studies, Kampala International University, Tanzania.

PISA (2012). *Program for International Student Assessment.* Field trial problem solving framework. Retrieved from http://pisa.iacm.forth.gr/org.

Raoano, M. J. (2016). *Improving Learners' Mathematics Problem Solving Skills and Strategies in the Intermediate Phase: A Case Study of a Primary School in Lebopo Circuit.* Dissertation Submitted in fulfillment of the requirements for the degree of Masters in Education in Mathematics Education, Faculty of Humanities (School of Education) at the University of Limpopo.

Saygılı, S. (2017). Examining the problem solving skills and the strategies used by high school students in solving Non-routine problems, *E-International Journal of Educational Research*, 8 (2), 91-114.

Styer, D. (2002). *Solving problem in physics.* Retrieved on 15th May 2012 from http://www.oberlinedu/physics/dester/solving - problem/html.

Su, H. F., Ricci, F. A. & Mnatsakanian, M. (2016). Mathematical teaching strategies: Pathways to critical thinking and metacognition. *Journal of Research in Education and Science, 2*(1), 190-200.

Szabo, A. (2017). *Mathematical abilities and mathematical memory during problem solving of gifted pupils.* Academic Dissertation for the Degree of Doctor of philosophy in Mathematic Education at Stockhom University,