IOSR Journal of Mathematics (IOSR-JM)
e-ISSN: 2278-5728, p-ISSN: 2319-765X. Volume 17, Issue 2 Ser. IV (Mar. – Apr. 2021), PP 28-36
www.iosrjournals.org

Exploratory Analysis of Problem Solving Based Learning for Mathematics Skills Acquisition in Tertiary Institutions

Iluno, Christiana[1] And Ebole Alpha[2]
[1]*Department of Mathematics & Statistics, Lagos State Polytechnic, Ikorodu, Lagos.*
[2]*Department of Computer Science, Lagos State Polytechnic, Ikorodu, Lagos.*

Abstract
Glaring neglect of policy as presented in the national policy on education that requires teachers to make instruction concept and skill centered illustrates a major way in which standards are often compromised in the tertiary institution learning system. The focus is on teaching mathematical topics through problem-solving contexts and inquiry-oriented environments which are characterized by the teacher helping students conduct a deep understanding of mathematical ideas and processes by engaging them in doing mathematics. The study was carried out using a sample size of 350 students of a tertiary institution in Nigeria. It was a non-equivalent quasi-experimental study that was guided by three hypotheses. Problem Solving Mathematics Achievement test (PSMAT) instrument with a reliability coefficient of 0.78 was used as pre, post, and delayed tests through the reshuffling of selected questions each time. The data obtained were presented using demographical representations and analyzed using mean and standard deviation, while the hypotheses were tested at 0.05 significant level using a Two-way Analysis of covariance (ANCOVA). Results showed that the experimental group outscored the control group significantly on the post-test and delayed test which showed that students have a very good command of basic knowledge and skills. These findings will serve as a reference for educators in improving the learning and teaching of mathematics in tertiary institutions.
Keywords*: Problem-solving, Skills, Cognitive, Polya, Retentive, Creativity*

Date of Submission: 10-04-2021 Date of Acceptance: 26-04-2021

I. Introduction

Each society expects from its education system that it enables the individuals to become effective problem solvers in their real-life (Walker & Lofton, 2003; Chin & Chia, 2004). The roots of problem-solving learning are found in Dewey's thoughts, "that learning by experimentation or doing is more lasting" (Dewy, 1938). Problem-solving is how to learn independently. It is the most convenient approach to achieve the aims of the teaching-learning process. (Gallagher,1997 & Lambros, 2002. Yager (2000) has stated that we live in a dynamic society in which social-political and technological conditions are changing continuously, so educators should analyze and evaluate the trends to decide an appropriate curriculum and method of instruction that will make students ready for a real-life situation. In this era of unprecedented breakthroughs in technology and constant change in many aspects of life, educators are challenged more than ever before with the need to develop students who will be adaptable in fast-changing environments. This calls for equipping students with better thinking skills and learning abilities. Concomitant with the quest for the development of skills on creativity and enterprise is the call for a paradigm shift in education (Seng, 2001). Mathematics is a key subject in engineering education and training, which form the foundation of technical manpower development of any nation. Mathematical skill is one of the most important to learn and also one of the most complex to teach. The main goal in teaching mathematics is that students develop a generic ability to solve real-life problems and apply mathematics in real-life situations. One of the main difficulties in teaching mathematical concepts is the fact that many skills are needed for a learner to be an effective problem solver. Also, these factors and skills make the teaching complex. Learning mathematical facts and contents is important but it is not enough. Students should learn how to use these facts to develop their thinking skills, solve problems and relate them to real-life problems. Mathematical educators have accepted the idea that the development of problem-solving ability deserves special attention and that one of the most important components in any mathematics curriculum is genuine mathematical problem-solving. Many writers have emphasized the importance of problem-solving as a means of developing the logical thinking aspect of mathematics. Resnick (1989) expressed the belief that "school should focus its efforts on preparing people to be good adaptive learners so that they can perform effectively when situations are unpredictable and task demands change". Cockcroft (1999) also advocated problem-solving as a means of developing mathematical thinking as a tool for daily living, saying that problem-

solving ability lies at the heart of mathematics because it is how mathematics can be applied to a variety of unfamiliar situations.

II. Literature Review

Problem-solving has special importance in the study of mathematics. Problem-based teaching through a problem-solving approach means using problems, questions, or tasks that are intellectually challenging and invite mathematical thinking through both mathematical content and mathematical processes in our students. The primary goal of mathematics teaching and learning is to develop the ability to solve a wide variety of complex mathematics problems and be able to relate them to real situations

2.1 PROBLEM SOLVING BASED LEARNING AND MATHEMATICS

Okereke (2006) stated that mathematics is the science of things that have a pattern of regularity and logical order and finding and exploring the regularity. Mathematics is the foundation of science and technology and the functional role of mathematics to science and technology is multifarious, that no area of science, technology, and business enterprise escapes its application. Besides its importance, it is observed that mathematics is one of the most poorly taught, widely hated, and abysmally understood subjects in schools. He further stated attributed students' poor performance to factors such as the society's view that mathematics is difficult, shortage of qualified teachers, lack of mathematics laboratory, and lack of attractiveness and novelty in teaching methods. Problem-based learning is a model which centered on students, develops active and motivated learning, problem-solving skills, and broad field knowledge, and is based on deep understanding and problem-solving. (Major et al, 2000) In those classrooms in which the problem-based learning method is used for the instructional process, the students take much more responsibility for their learning. They are independent and long-life learners and can continue to learn their whole life. Stanic and Kilpatrick (1989) traced the role of problem-solving in school mathematics and illustrated a rich history of the topic. Learning to solve problems is the principal reason for studying mathematics. Therefore, it is useful to develop a framework to think about the processes involved in mathematics problem-solving. Most formulations of a problem-solving framework in textbooks attribute some relationship to Polya's (1973) problem-solving stages. However, it is important to note that Polya's "stages" were more flexible than the "steps" often delineated in textbooks. These stages were described as ***understanding the problem***, ***making a plan***, ***carrying out the plan***, and ***looking back***. To Polya (1965), problem-solving was a major theme of doing mathematics, and "teaching students to think" was of primary importance. "How to think" is a theme that underlies much of genuine inquiry and problem-solving in mathematics. However, care must be taken so that efforts to teach students "how to think" in mathematics problem solving do not get transformed into teaching "what to think" or "what to do." The linear nature of the models used in numerous textbooks does not promote the spirit of Polya's stages and his goal of teaching students to think. By their nature, all of these traditional models have the following defects:

1) They depict problem-solving as a linear process.
2) They present problem-solving as a series of steps.
3) They imply that solving mathematics problem is a procedure to be memorized practiced, and Habituated
4) They lead to an emphasis on answer getting.

Problem-solving is an important component of mathematics because it is the single-vehicle that seems to be able to achieve at school level all three of the values of mathematics at the outset of this paper: functional, logical, and aesthetic. Considering how problem-solving is a useful medium for each of these. It has already been pointed out that mathematics is an essential discipline because of its practical role to the individual and society. Through a problem-solving approach, this aspect of mathematics can be developed. Presenting a problem and developing the skills to solve a problem is more motivational than teaching the skills without context. Such motivation gives problem-solving special value as a vehicle for learning new concepts and skills or the reinforcement of skills already acquired. Approaching mathematics through problem-solving can create a context that simulates real life and therefore justifies the mathematics rather than treating it as an end in itself. For the problem of this reason solving can be developed as a valuable skill in itself, a way of thinking rather than just a means to an end of finding the correct answer.

2.2 PROBLEM SOLVING BASED LEARNING METHOD/MODEL

In the problem-based learning model, the students turn from passive listeners of information receivers to active, free self-learner and problem solvers. It also shifts the emphasis of educational programs from teaching to learning. It enables the students to learn new knowledge by facing the problems to be solved instead of feeling bored. Problem-based learning affects positively certain other attributes such as problem-solving, information acquisition, and information sharing with others, group works, and communication, etc. Again problem-solving is a deliberate and serious act, involves the use of some novel method, higher thinking, and systematic planned steps for the acquisition set goals. The basic and foremost aim of this learning model is the

acquisition of such information based on facts (Yuzhi, 2003 & Mangle, 2008). According to Gallagher et. al,(1999) in the problem-solving based learning environment, students act as professionals and are confronted with problems that require clearly defining and well-structured problems, developing a hypothesis, assessing, analyzing, utilizing data from different sources, revising initial hypothesis as the data collected developing and justifying solutions based on evidence and reasoning. The practice of problem-solving based learning is richly diverse as educators around the world and in a wide range of disciplined have discovered it as a route to innovating education, The educators used the problem-solving method as an educational tool to enhance learning as a relevant and practical experience, to have students' problem-solving skills and to promote students' independent learning skill. Eng (2001) opined problem-based learning as a philosophy aim is to design and deliver a total learning environment that is holistic to student-centered and student empowerment. It is recommended that problem-solving be a focus of mathematics teaching because, they say, it encompasses skills and functions which are an important part of everyday life. Furthermore, it can help people to adapt to changes and unexpected problems in their careers and other aspects of their lives. Problem-solving should underlay all aspects of mathematics teaching to give students an experience of the power of mathematics in the world around them. They see problem-solving as a vehicle for students to construct, evaluate and refine their theories about mathematics and the theories of others. A further reason why a problem-solving approach is valuable is as in aesthetic form. Problem-solving allows the student to experience a range of emotions associated with various stages in the solution process. Mathematicians who successfully solve problems say that the experience of having done so contributes to an appreciation for the 'power and beauty of mathematics,' the " joy of banging your head against a mathematical wall, and then discovering that there might be ways of either going around or over that wall" Problem-based learning have the following advantages:

• Development of Long-Term Knowledge Retention
• Use of diverse Instruction Types
• Continuous Engagement
• Development of Transferable Skills
• Improvement of Teamwork and Interpersonal Skill

2.3 PROBLEM-SOLVING BASED APPROACH

Problem-solving has generally been accepted as a means for advancing thinking skills. Specific characteristics of a problem-solving approach include:

• Interactions between students/students and teacher/students
• Mathematical dialogue and consensus between students
• Teachers providing just enough information to establish the intent of the problem and students clarifying, interpreting, and attempting to construct one or more solution processes
• Teachers accepting right/wrong answers in a non-evaluative way
• Teachers guiding, coaching, asking insightful questions, and sharing in the process of solving problems
• Teachers knowing when it is appropriate to intervene, and when to step back and let the pupils make their way
• A further characteristic is that a problem-solving approach can be used to encourage students to make generalizations about rules and concepts, a process that is central to mathematic.

2.4 TEACHERS' ROLE IN PROBLEM-BASED LEARNING ENVIRONMENT

The most important achievement of a teacher is to help his/her students along the road to independent learning. In problem-based learning, the teacher acts just as a facilitator, rather than a primary source of information or dispenser of knowledge. Roh, (2003) argued that within problem-based learning environments, teachers' instructional abilities are more critical than in conventional teacher-centered classrooms. Beyond presenting mathematical knowledge to the students, teachers in problem-based learning environments must engage students in marshaling information and using their knowledge in applied real settings. Evidence of poor performance in mathematics by tertiary school students highlights the fact that the most desired technological, scientific, and business application for mathematics cannot be sustained. This makes it paramount to seek a strategy for teaching mathematics that aims at improving its understanding and performance by students practically (Okigbo & Osuafor, 2008). Problem-solving as a method of teaching may be used to accomplish the instructional roles of learning basic facts, concepts, and procedures, as well as goals for problem-solving and applying to real-life problems. Problem-solving is a major part of Mathematics has many applications and often those applications represent important problems in, mathematics. We include problem-solving in school mathematics because it can stimulate the interest and enthusiasm of the students (Wilson, 1993).

III. Contribution Of This Paper To The Literature

- This study proposes a problem- solving based teaching method to help students learn mathematics better and longevity in retention of mathematical skills learnt..
- The problem-solving based teaching method provided in this paper will assist in overcoming the difficulties in learning mathematics for students.
- This study highlights that problem-oriented teaching method has shown a significant positive effect on enhancing students' mathematics achievement and reducing the differences in scores between problem-solving based teaching methods with traditional teaching methods.

IV. Statement Of Problem

The alarming rates of failure in mathematics courses in tertiary institutions have caused a lot of damage to our technological growth and development. Since most of the courses learned cannot be related to real-life situations by graduates. From findings, it shows that Nigeria students are competing for the last position and not the best. Researchers have also emphasized the use of new methods for teaching and learning mathematics at tertiary institutions apart from the lecture method but to no avail.

V. Objectives And Hypotheses

The major purpose of this study was to investigate the effect of using a problem-solving-based method in teaching tertiary students in mathematics. Following were the main objectives of the study;

i. To compare the achievement of students taught by problem-solving method and students taught by the conventional method.

ii. To determine the effect of the use of the problem skill teaching approach and lecturing (conventional) teaching method on students' mean performance scores.

iii. To compare the use of problem skill approach and conventional teaching methods on the students' mean retention and creativity scores

For the achievement of the above objectives following null hypotheses were tested.

1. There is no relative difference between the mean performance scores of students taught using PSTA and those taught using the conventional approach (CTA).
2. There is no relative difference in the mean retention scores of students taught with PSTA and those taught with the conventional approach (CTA).

VI. Method And Procedure

Population and Sample

This study was a non-equivalent quasi-experimental design due to the large coverage involved and randomizing might not be effective intact classes were used. The population comprised of students of Lagos State Polytechnic. The choice of this population was preferred since polytechnic is the bedrock of science and technology of any nation. The sample for the study was 350 students multi-stage sampling was involved. First, two schools were sample out of six schools: School of Pure and Applied Sciences and School of Engineering. All students were divided based on into two groups as Experimental and Control groups through random sampling technique: School of Pure and Applied Sciences was assigned the experimental group while School of Engineering was assigned, control group. The experimental group was taught with Problem-Skill Based Teaching Approach while the control group was taught with the Conventional Teaching Approach (CTA)/lecture method. The control group comprised 171 male and female students while the experimental group comprised 179 male and female students. A total number of four mathematics lecturers was used, to maintain authenticity the mathematics lecturers were of equal qualification and were given orientation on problem-solving-based teaching. The two lecturers to teach the control groups used the Conventional Teaching Approach (CTA) while the other two lecturers taught the experimental group using PSTA. The two groups were taught the same courses – Calculus and Algebra. Finally, questions selected for the PSMAT were picked from the courses listed above. Length of teaching was equally distributed and each classroom section was supervised by the researcher.

VII. Research Design And Instrumentation

After reviewing the related literature and consultation with experts the instrument used in the study was called *the Problem-Solving Mathematics Achievement test* ***(PSMAT)*** whose content was validated by the doctoral committee and two mathematics education experts. The instrument was pilot tested with 50 students in a tertiary institution not participating in the study but within the same area of study. PSMAT was used for pretest, post-test and delayed tests to collect data and in each case, the questions were reshuffled. A 50- items PSMAT developed and tested based on the table of specifications. The pre-test was given to the entire group

before the commencement of the teaching and learning. After ten weeks of teaching and learning, PSMAT was rearranged and administered again to measure creativity and retention ability.

VIII. Data Analysis

We performed descriptive statistical analyses, such as the mean and standard deviation, and inferential statistical analysis, such as t-test, to determine the effect of the two different teaching methods (i.e., the problem-oriented and traditional teaching methods) on students' mathematics learning. In this study, all statistical analysis procedures and results were calculated using SPSS, and the statistical significance was set at 0.05 levels with two-tail tests.

IX. Results

Scores	PRE-TEST		POST TEST		DELAYED TEST	
	Experimental Group	Control Group	Experimental Group	Control Group	Experimental Group	Control Group
0-19	60	65	22	40	08	33
20-39	58	43	25	45	26	48
40-59	46	32	44	55	40	58
60-79	15	31	78	31	78	32
80-79	-	-	10	-	27	-

TABLE 1: Frequency Distribution Table for various groups under Pre-test, Post-test, and Delayed test.
Table 1 shows the grouped frequency distribution table for the experimental group and control group with the frequencies of performances of students in each class interval during the pre-test, post-test and delayed-test.

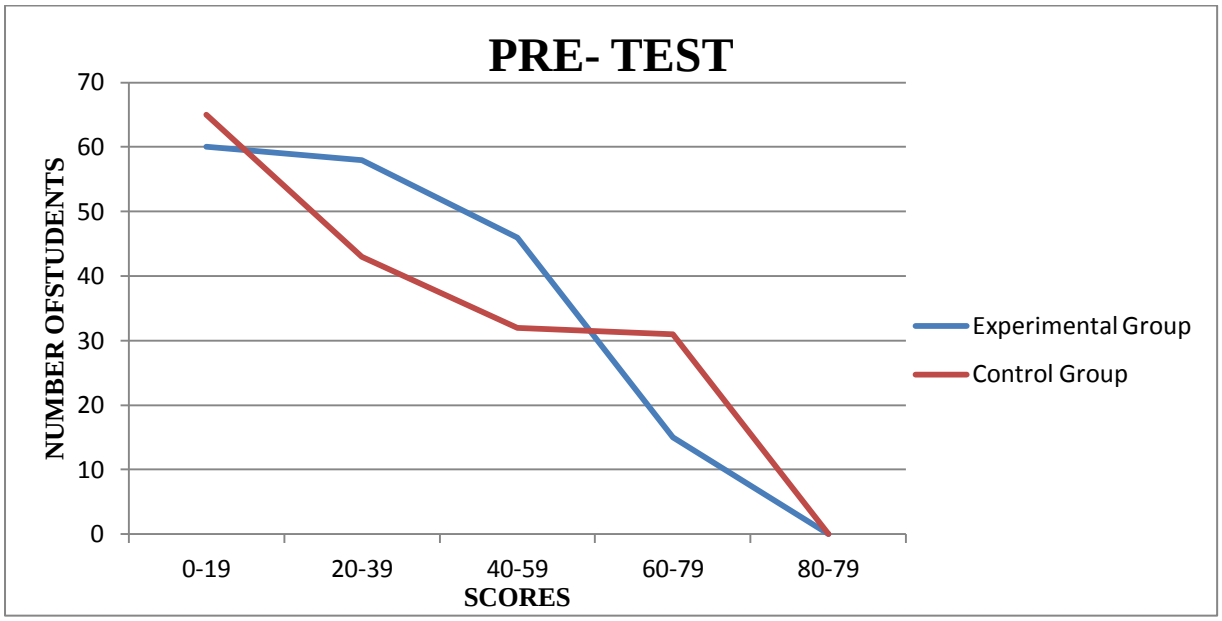

Fig1: Line graph for Pre-test generated through SPSS

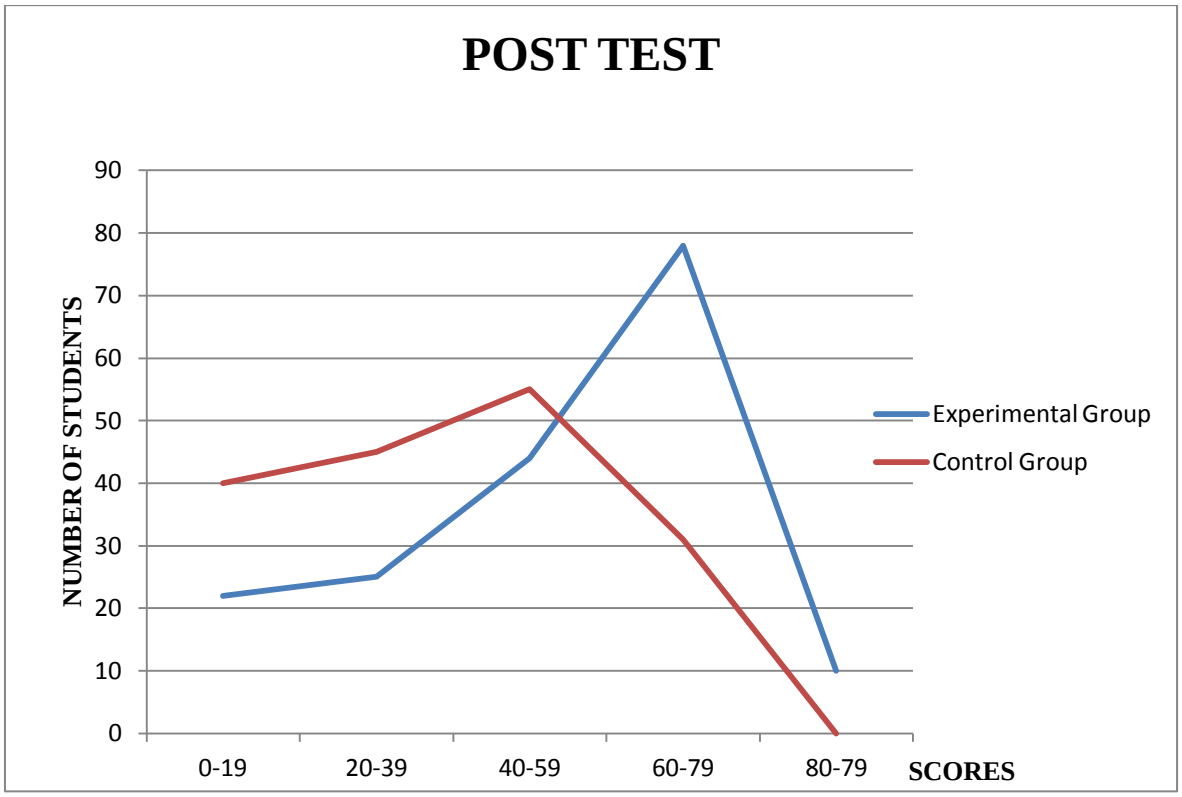

Fig 2: Line graph for Post-test generated through SPSS

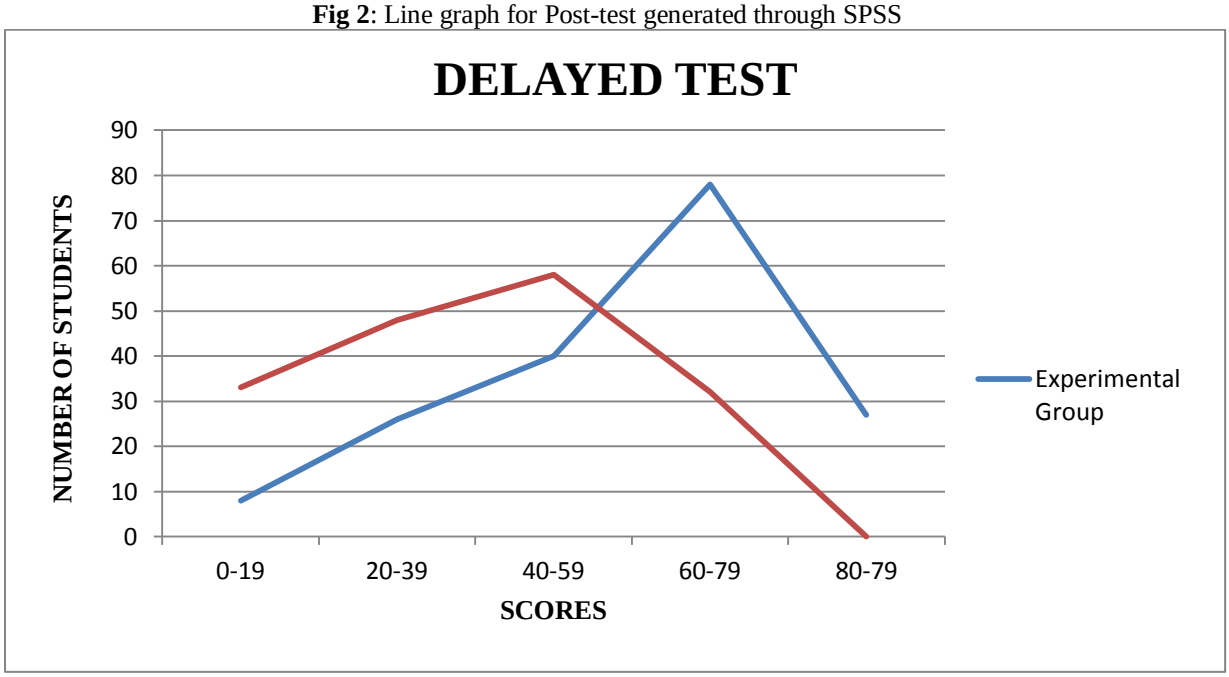

Fig 3: Line graph for Delayed-test generated through SPSS

Fig1, 2 and 3 were generated through the SPSS and it shows the peak and point of intersection for the pre, post and delayed tests performance. In fig 3.the experimental group performed very well than others, not minding that the delayed test was given after 10 weeks of teaching and learning.

TEACHING METHOD	TYPE OF TEST	N	MEAN ($\bar{X}$)	STANDARD DEVIATION
Problem solving mathematics Teaching Approach(ETA)	Pre-test	179	31.29	19.17
	Post- test	179	52.74	45.38
	Delayed-test	179	69.55	31.07
Conventional Teaching	Pre-test	171	32.89	25.48

Approach(CTA)	Post- test	171	38.50	20.76
	Delayed- test	171	39.90	19.09

TABLE 2: Mean Performance Scores and Standard Deviation for the Experimental and Control group.

Table 2, shows the mean scores and standard deviation of each type of test given. From the table, the delayed test for the experimental group has the highest mean score 69.55 and the standard deviation was 31.07(lowest) while the control group's mean score 39.90 and with the lowest standard deviation 19.09.

Source of Variance	Type III Sum of squares	DF	Mean Square	F	Sig	REMARK
Corrected Model	5554.400	4	1110.880	53.1152	.001	s
Intercept	12250.000	1	12250.000	56.124	.000	s
PRE PSMAT	6.400	1	6.400	.306	.000	s
Method	5548.000	4	1387.000	66.364	.001	s
Error	83.600	4	20.900			
Total	17888.000					
Corrected Total	5638.000					

S = Significant at $\alpha = 0.05$.

TABLE 3: Two way ANOCOVA results on subjects performance scores in PSMAT.

Source of Variance	Type III Sum of squares	DF	Mean Square	F	Sig	REMARK
Corrected Model	5036.600	5	1007.320	18.069	.oo4	s
Intercept	12816.000	1	12816.000	229.891	.000	s
POST- PSMAT	.000	1	.000	.000	.000	s
Method	5036.600	4	1259.000	22.586	.001	s
Error	223.000	4	55.750			
Total	18076.000					
Corrected Total	5259.000					

S = Significant at $\alpha = 0.05$.

TABLE 4: Two way ANOCOVA results on subjects performance scores in PSMAT for retentive and creativity

RESULTS

The results of the study were presented according to the research questions and hypotheses

Question 1 What is the relative effect of the use of PSTA and CTA on students' mean performance scores. From Table 1 and 2 the answer to this question is found Table 1 shows the raw scores of the students in column2 and 3 were raw data of scores were tabulated. The Experimental group performance was outstanding after the administration of the post test. Also Table 2 shows the mean scores of students taught by PSTA as 52.74 while standard deviation was 45.38 also when the mean score of students taught through CTA was 38.50 and the standard deviation was 20.76. This shows that PSTA is more efficiency than CTA.

Hypothesis1. There is no relative significant difference between the using of PSTA and those taught using the conventional approach. The analyzed data for test hypothesis1 is found in Table 3. Result in table 3 shows that the difference between the mean performance scores of those taught with PSTA and those taught with the conventional approach is significant at 0.05 alpha level. Therefore, the hypothesis 1 was rejected.

Question 2 What is the relative effect of the use of Problem-solving oriented teaching approach and conventional teaching methods on the student mean creativity scores? From table 1, the raw score of the students under the experimental and control group were shown. Table1 shows that the experimental group performed highly and the rate of student that scored 60-99 was extremely high. Also, the column for the control group showed that the student scored low marks compared to the post test column. Table 2 showed the mean

score and standard deviation for the delayed test. For the experimental group we have 69.55 and 31.07 respectively which shows that Problem-solving (PSTA) is more efficiency and effectively in teaching Mathematics for concretize and creative learning.

Hypothesis 2 There is no relative difference in the mean retention scores of students taught with PSTA and those taught with the conventional approach. The analyzed data for the test hypothesis 2 is show in table 4. The table shows that the hypothesis 2, was rejected.

X. Discussion

This study has shown that students taught with PSTA had a higher mean performance mean score (52.74) than their counterparts taught with a conventional approach with (45.38) mean performance score. This was further evident in Table 3 which reveals the difference in performance between the experimental and control groups which was significant ($F1.4=66.364$ $p<0.001$). It was noticed that the students taught with PSTA were able to actualize and concretize the concepts and skills taught easily since there was a link between the content and their immediate methodology used and aspect of the learning. This finding was by Yu Han et. al, (2018). The teaching was done in a practical-oriented way and it flows in two traffic ways that are, from home to school and from school to one's everyday living. Thus, the abstract nature of teaching and learning mathematics concept has been reduced to a minimum or zero levels. The high performance of students taught with PSTA had shown that PSTA is a practical oriented teaching approach which imbibed into itself problem – solving and it could be an effective teaching approach to curb poor performance of mathematics students in institution of higher learning in Nigeria which is due to inappropriate teaching approach. Table 4 reveals that the difference between the retention and creativity mean scores of experimental and control groups is statistically significant ($F1.4=22.586$ $p<0.001$). This finding is in agreement with that of B, Uloko (2009) and disagrees with Iji (2002) who in his study found that the differences were not statistically significant.

XI. Conclusions And Recommendations

This study exposed the fact that Problem Solving Based Teaching Approach is more effective than the Conventional Teaching Method. This study proved that problem solving is more effective method of instruction for teaching and learning mathematics as compared to traditional (lecture) method of teaching. Therefore the teachers of mathematics should use problem solving method to improve the academic achievements of the students. Extensive training program, seminars and workshops should be organized for mathematics lecturers in tertiary institutions to employ problem solving method in the classrooms. For future research, the researchers' suggestions are as follows:

- Qualitative research should also be considered. The problem-solving oriented teaching method proposed in this paper combined with ethno-mathematics methods, This process may also facilitate the students' improvement in mathematics learning.
- The problem-solving oriented teaching method proposed in this paper combined with other teaching methods, such as computer-assisted instruction, should be investigated regarding promoting students' speed, quality and quantity of mathematic skills learning.
- Researches should be carried out on other factors, such as gender, age and family background, which were not considered in this study.

References

[1]. Chang, S.C., et. al. (2001). An exploratory analysis of current pedagogical practices in primary mathematics classrooms. *The NIE Researcher, 1*(2), 7-8.

[2]. Chin, C. & Chia, L. G. (2004). Problem Based Learning using Students' Questions to drive Knowledge Construction *Science Education*, 88(5), 707-727.

[3]. Dewey, J. (1933). How we think: A restatement of the relation of reflective thinking to the educative process. Boston: Heath.

[4]. Dewey, J. (1938). *Experience and Education*. A Touchstone Book, Kappa Delta Pi, New York.

[5]. Eng, C.S. (2001). *Problem Based Learning-Educational Tool or Philosophy*. University of Newcastle, Australia.[Online] Available: http://edweb.sdsu.edu/clrit/learning_tree/PBL/PBLadvantages.html.

[6]. Farooq, R.A 1980. A Comparative Study of Effectiveness of Problem Solving Approach and Traditional Approach of Teaching Social Studies to Secondary Schools Students (Unpublished Ph.D. thesis) University of Punjab Lahore, (Pakistan).. PP. 14-19, 21.

[7]. Gallagher, S. A. (1997). Problem-Based Learning: Where did it come from, what does it do, and where it is going? *Journal for the Education of the Gifted*, 20(4), 332-362.

[8]. Gallagher, S. A., Stephien, W. J., Sher, B. T. &Workman, D. (1999). Implementing Problem-Based Learning in Science Classrooms. *School Science and Mathematics*, 95(3), 136-146

[9]. Henderson, K. B. & Pingry, R. E. (1953). Problem Solving in mathematics. In H. F. Fehr (Ed.), The learning of mathematics: Its theory and practice (21st Yearbook of the National Council of Teachers of Mathematics) (pp. 228-270). Washington, DC:

[10]. Iji CO (2002) .Effects of logo and basic programmes on achievement and retention in geometry of junior secondary school students. Unpublished Ph. D Thesis. University of Nigeria, Nssuka.

[11]. Kousar, Perveen, (2010) Effect of the Problem-Solving Approach on Academic Achievement of Students in Mathematics at the Secondary Level. Contemporary Issues in Education Research Volume 3, Number 3.
[12]. Lambros, A. (2002). *Problem Based Learning in K-8 Classroom: A Teacher Guide to Implementation. California.* Corvin Press Inc.
[13]. Luzmanuel, S.T.1990. Dissertation Abstract Part2 http://www.ntef.com/html/lib/unil/192197.html. Search on 15-08-2006 Kyeong, K.M. 1997. Dissertation Abstracts: Part-5. http://www.ntlf.com/html/lib/umi/1997e.htm Search on 12-15-2006.
[14]. Major, C. H., Baden, M. S. & Mackinnon, M. (2000). Issues in Problem Based leaning: A Message from Guest Editors. *Journal on Excellence in College Teaching*, USA, Web Edition, 11, 3.
[15]. Mangle, S.K. (2008).Advanced Educational Psychology (2nd Edi).Prentice Hall of India New Delhi.Pp.378-380.
[16]. Nuzum, M.D. 1991. The Effects of Instructional Model Based on the Information Processing Paradigm on the Disabled Students in Siddiqui, M.H. (Ed). Model of Teaching Theory and Research. Ashish Publishing house Punjab Bagh New Delhi India. P.84.
[17]. Okereke, S. C. (2006). Effect of prior knowledge of implementing of mathematical tasks/concepts to career types and gender on students' achievement, interest and retention. In U. Nzewi (Ed) STAN *Proceedings of the 47th Annual Conference*, 253-259.
[18]. Okigbo, E. C. & Osuafor, A. M. (2008). Effect of using Mathematics Laboratory in Teaching Mathematics on the Achievement of Mathematics Students. *Educational Research and Review*, 3(8), 257-261.
[19]. Polya, G. (1965). Mathematical discovery: On understanding, learning and teaching problem solving (vol. 1). New York: Wiley.
[20]. Polya, G. (1973). How to solve it. Princeton, NJ: Princeton University Press. (Originally copyrighted in 1945).
[21]. Polya, G. (1980).On Solving Mathematical Problems in High School. In S. Krulik (Ed.) Problem solving in School Mathematics, (pp1-2) Reston, Virginia: NCTM.
[22]. Riasat Ali, et al (2010). Effect of Using Problem Solving Method in Teaching Mathematics on the Achievement of Mathematics Students. Asian Social Sciences. Vol 6. No2.
[23]. Roh, K. H. (2003). Problem Based learning in Mathematics. *ERIC Clearing house for Science Mathematics and Environmental Education*. [Online] Available: http://www.ericdigests.org/2004-3/math.html.
[24]. Rustam E. et al. (2019). Improving Students' Mathematical Problem Solving Ability and Self-Efficacy through Guided Discovery Learning in Local Culture Context International Electronic Journal Of Mathematics Education e-ISSN: 1306-3030. Vol. 14, No. 1, 61-72. https://doi.org/10.12973/iejme/3966
[25]. Stanic, G., & Kilpatrick, J. (1988). Historical Perspectives on Problem Solving in the Mathematics Curriculum. In R. I. Charles & E. A. Silver (Eds.), the teaching and assessing of mathematical problem solving (pp. 1-22). Reston, VA: National Council of Teachers of Mathematics
[26]. Uloko E S, Ogwuche J (2007). A practical approach of the use of ethno mathematics in teaching Locus. In M.J Adejoh & C O Iji, Innovations in teaching and learning Makurdi: Adeka printing and publishing company Ltd. pp276-288.
[27]. Walker, J. T. & Lofton S. P. (2003). Effect of Problem Based Learning Curriculum on Students' Perceptions of Self-directed Learning. *Issues in Educational Research*, 13, University of Mississippi Medical Centre
[28]. Wilson, P.S. (1993). Research Ideas for the Classroom: High School Mathematics. National Council for Teachers of Mathematics, Research Interpretation Projects, Vol. 3,Macmillan: New York, USA. 154-158.
[29]. Yager, R. E. (2000). A vision for what science education should be like for the first 25 years of a new millennium. *School Science and Mathematics*, 100, 327-341.
[30]. Yuzhi, W. (2003). Using Problem-Based Learning and Teaching Analytical Chemistry. *The China Papers*, July, 28-33.

Iluno, Christiana, et. al. "Exploratory Analysis of Problem Solving Based Learning for Mathematics Skills Acquisition in Tertiary Institutions." *IOSR Journal of Mathematics (IOSR-JM)*, 17(2), (2021): pp. 28-36.