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## PROBLEM SOLVING: A STRATEGY FOR IMPROVING STUDENT'S MATHEMATICAL SKILLS

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### ABSTRACT

The paper highlighted on problem solving instructional strategies as a means of supporting students' mathematical skills in solving problems. The concept of problem solving instructional strategies; types of problem solving instructional strategies by different authors; concept of students' mathematical skills; problem solving instructional strategies and students mathematical skills; summary; conclusion and recommendation.

**KEYWORDS:** Problem solving instructional strategies; student's mathematical skills

### 1. INTRODUCTION

Life is generally about solving problems and every individual engage in problem solving knowingly or unknowingly. This can either be formally or informally in the process of earning a living. Individuals and organizations engage in problems solving differently depending on the nature and complexity of the problem for earning their living. Thus, the success of people in their life time is highly determined by their ability to make use of good problem solving strategies that will foster thinking skills (Jonassen, 2004). Foshay (2003) described problem solving as the basic skills that are necessary for every individual and learners in particular to enable them have an integrated learning environment that will support them use higher order thinking skills. Therefore, teaching and learning organization should incorporate problem solving as a major component of the curriculum. Hence it needs to be developed by individual and learners. According to Bureau of Exceptional Education and Students Services (BEESS, 2010) problem solving processes are very useful in mathematics, sciences, social sciences and other subjects which enable students to deal more effectively and successfully with most types of mathematical problems and encourages them to develop and discover their potential in tackling problems of any situation. In the same vein, Sullivan (2011) noted that problem solving is the major focus of research, curriculum and teaching of the modern world, hence individual, researchers, teachers, students and curriculum expert should be well grounded on problem solving strategies. Problem solving is central to mathematics education that determines the level of success and skills of

students in mathematics (Aydogdu&Kesan, 2014). Yuan (2016) stated that problem solving skills and strategies will create a labor market that can help to sustain the growing-based knowledge economy of a nation through introducing the students to skills that enable them to improve in Science, Technology, Engineering and Mathematics (STEM).

However, it is common knowledge that in many situations, daily living problems and mathematics problems in particular tend to confuse, frustrate and disturb many people. In some situations, people discard problems that they cannot solve even if it forms fundamental aspect of their progress. This could lead to setback in their activities and life that may affect the society in general. Ganina and Voolaid (2007) reported that in mathematics teaching and learning, students mostly tend to develop fear of the subject, put in less interest and achieve poorly compared to even other science subjects like biology and chemistry. In most situations, when students were asked to solve a problem with an unknown variable, they accept defeat that they cannot solve such problem without even trying it which gradually affects their progress in the subject. National Council of Teachers of Mathematics (NCTM, 2014) reveals that organizations, institutions of learning and individuals encounter problems that affect their progress either by delaying it or hindering its development. This leads to decrease in almost daily based on the quality and quantity of teachers and students in mathematics discipline. Problem solving is a goal of mathematics which mathematicians do not recognize and often end up not achieving what they tend to achieve in mathematics (Ball, 2005). Therefore, the paper stresses the need for problem solving in developing student's mathematics skills.

### **Problem Solving as Instructional Strategies**

Everyone has problems in life to solve, in most situations we are able to quickly solve problems without much trouble by either coming up with a quick solution or use a strategy that worked in the past. Problems become more difficult when there is no obvious solution and strategies that have been tried in the past. These types of problems cause a great deal of stress and anxiety, and they require a new and different strategy (Vosolou, 2008)). Moursand (2016) noted that problem solving is a study of unified theme in education and in the study of various discipline that exposes students to the problems and knowledge of a very wide range of disciplines. It also focuses on helping students learn how to learn and learn to take responsibility of their own education. Jonassen (2004) described problem solving as a uniform process of Identifying potential problems, defining and representing the problem, exploring possible strategies, acting on those strategies, looking back and evaluating the effects of those activities. 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, and each requires different forms of teaching and learning support. For example, solving a mathematics problem calls on a different set of content knowledge and skills compared to other areas that do not involve quantitative reasoning. Therefore, problem solving can be viewed as a goal, process, basic skills, instructional strategy, mathematical thinking and teaching approach. However, most researches regard

problem solving as the process of achieving a solution. In view of that, Polya (1957) described problem solving as means of finding a way out of difficulty, a way around an obstacle, attaining an aim which was not immediately attainable. Problem solving is recognized by Stancey (2005) and Andersan (2009) as an important life skill involving a range of processes including analyzing, interpreting, reasoning, evaluating and reflecting. Problem solving is therefore a principal component of mathematics education from the time of its emergence as a self-sufficient science. According to Voskolou (2008) a problem is only a problem if you have to use systematic skills and procedures to solve the problem. A problem that has no surprises and can be solved comfortably by routine or familiar sequence is considered to be an exercise. Similarly, Hines (2008) is of the view that mathematics problem solving involves the ability to read process and solve mathematical situation or ability to personally construct meaning of mathematical experience. Furthermore, Schoenfeld (2007) opined that problem solving as used in mathematics education refers to the process wherein students encounter a problem or a difficulty. That is a question which they do not have an immediate solution nor a procedure that they directly apply to get an answer.

Problem solving according to Moursand (2016) consists of moving from a given initial situation to a desired goal situation. Meaning a 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 exact same situation can be a problem for one person and not a problem (perhaps just a simple activity or routine exercise) for another person. Problem solving is described as a series of hierarchical and step-wise set of processes that problem solvers and students undertake to reach solution of a given problem (Jajua, 2012). It is also defined by Su, Ricci and Mnatsakanian (2016) as a process of finding solution to difficult or complex issues or a process of working through detail of a problem to reach a solution. This may include mathematical or systematic operation and can be gauged by an individual's critical thinking skill. Problem solving consists of using generic or ad hoc methods in an orderly manner for finding solution to problems. Pual, Hwa and Lau (2007) see problem solving as a process of finding solution to a problem when the method is not known to the problem solver, and the problem solver has to use strategic skills to select the appropriate technique for the solution. Okoronka (2004) described problem solving as a process of bridging the gap between the learner's existing knowledge and solution to problem by accessing or keying into learner's previous knowledge which depends on the number of variables existing at the time when the experiences were formed. Therefore problem solving is important as a way of doing, learning and teaching science. It can provide the site for learning new concept and for practicing learned skills. Problem solving are strategies that can be best describe as different steps or approaches or teaching steps devices and adopted by various experts that are applied in solving mathematics problems and even problems of daily living. It is a precise step-by-step plan for a computational procedure that begins with an input value and yields an output value in a finite number of steps.

### **Types of Problem Solving Instructional Strategies**

With regard to importance and value attached to problem solving and problem solving instructional strategies, various problem solving instructional strategies developed by different authors that provide the systematic and logical procedures that need to be followed when solving mathematical problems include:

1. Williams and Carey (2003) six stages of problem solving involving
  - (1) identification of problem
  - (2) seeking out information and setting goals
  - (3) brainstorming
  - (4) describing the plan
  - (6) reviewing and revising.
  
2. Creative problem-solving model (Alexander, 2010) with three stages designated as follows:
  - (i) Understanding the problem
  - (ii) Generating ideas
  - (iii) Planning for action.
  
3. Ross (1988) cluster of skills for problem solving with four stages which are:
  - (i). Problem representation
  - (ii). Information retrieval
  - (iii). Information processing
  - (iv). Information reporting
  
4. Six Steps Problem Solving called “IDEALS” (Facione, 2007). The IDEALS are to Identify, Define, Enumerate, Analyze, List, and Self-Correct:

I	Identify the Problem: What is the real question we are facing?
D	Define the Context: What are the facts that frame this problem?
E	Enumerate the Choices: What are plausible options?
A	Analyze Options: What is the best course of action?
L	List Reasons Explicitly: Why is this best course of action?
S	Self-Correct: Look at it again ... What did we miss?
  
5. Styer (2002) problem solving strategy with three stages as follows:
  - (i) Strategy design
  - (ii) Strategy execution/tactics
  - (iii) Checking your answer

6. Polya's (1957) problem solving strategy with four stages

- (i). Understanding the problem
- (ii) Devising a plan
- (iii) carrying out the plan
- (iv) reflecting back

7. Rational decision making strategy (Green & Shapia, 2007) with five stages as follows:

- (i) Defining the situation/decision to be made
- (ii) Identify the importance criteria for the process and result
- (iii) Consider all possible solutions
- (iv) Calculate the consequences of these solutions versus likelihood of satisfying the criteria
- (v) Choose the best option

### **Mathematical Problem Solving Skills**

Mathematical problem solving skill is far more than the basic reproduction of accumulated knowledge. It involves a mobilization of cognitive and practical skills, creative abilities and other psychological resources such as attitude, motivation and values. Mathematical problem solving skill are not simple reproduction of domain-based knowledge rather as cognitive skills required in solving unfamiliar problems encountered in life and lying outside traditional curricular domain (PISA, 2012). Mathematical problem solving skill as defined by Dwyer, Hogan and Stewart (2014) is the ability or expertness of a problem solver in working through detail of a problem that will lead to its solution which may include mathematical or systematic operations. It can also be described as a gauge of an individual's critical thinking (Yuan, 2016). Protheroe (2007) stated that good mathematical problem solving skill increases students learning, confidence, independence, teamwork, creativity, persistence to problem solving and lets the problem solver see that not only can problems have more than one solution, but sometimes the same solution works for more than one problem.

Mathematical problem solving skills are activated when individuals encounter unfamiliar problems, uncertainties, questions, or dilemmas. Successful applications of the skills result in explanations, decisions, performances, and products that are valid within the context of available knowledge and experience and that promote continued growth in these and other intellectual skills (Foshay, 2003.). According to BEESS (2010) mathematical problem solving skill is a critical thinking that involves complex mental processes such as paying attention to details, selecting relevant information, analyzing carefully and skeptically, 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 problem solving skills as generic thinking skills are emphasized in a variety of content areas of curriculum planning documents across cultures. Students' mathematical problem solving skills demonstrate their capacity to think critically, communicate clearly, and solve

complex mathematical problems and apply knowledge in real-world settings (Su, Ricci & Mnatsakanian, 2016).

Mathematical problems solving skills can tax learner's intellect in different ways. In some problems, where the actual calculations that learners have to make to reach the right answer are obvious and the only difficulty that they might have is in doing the calculation correctly. In other problems, it is quite hard for learners to work out what kind of calculation they need to do to solve the problem, even when the calculation itself is an easy one. To solve this second kind of problem, the learner has to begin by reasoning about the quantities involved and this reasoning is called mathematical problem solving skill which is always about the relations between different quantities or between different states of the same quantity over time (Nunes, Bryant, Evans, Gottardis & Terlektsi, 2015). For example if Moses and Aisha have the same amount of money as each other, but then Moses gives Aisha N10. How much more money does Aisha have than Moses? The problem is presented to primary school children aged 9 to 11-years. Only about a quarter of them solved the problem correctly; two thirds answered that Aisha had N10 more than Moses. This would be right if only one of the quantities had changed. That is if Moses had given N10 to someone else, not Aisha, but in fact the story is about two changes, one in Moses amount of money and one in Aisha's. If Moses gave N10 away, he has N10 less than before, and Aisha has N10 more than before. The calculation needed,  $10 + 10$ , could hardly be simpler, but the solution, requires the children to deduce two relations and operate on these relations without knowing the quantities. Children's difficulties with this problem, and many other kinds of mathematical reasoning problems, led them to the conclusion that teaching them about mathematical problem solving skills, and showing them how important this reasoning skills can be, might help them through an important part of their mathematical learning. The need for such teaching is now quite widely recognized. The importance of learning to reason mathematically is also supported by strong evidence for the crucial role that problem solving skill plays in children's mathematical achievement in school.

### **Problem Solving as a means of Improving Learners Mathematical Problems Solving Skills**

The emphasis on problem solving instructional strategies in teaching and learning of science generally and mathematics in particular has become a global phenomenon by educators, curriculum experts and researcher due to role played by problem solving in enhancing students' learning. In view of the importance of problem solving instructional strategies, Foshay (2003) reported that problem solving instructional strategies become increasingly necessary for students to develop higher order thinking skills that enable them to improve their competencies in solving mathematical problem and enhance their performances. The author describe problem solving strategies as basic for learners to use their knowledge in a variety of domains, such as performing critical analysis of a mathematical problem and solving problems for improving the acquisition of scientific and technological literacy.

Aydoğdu and Keşan (2014) observed that problem solving as instructional strategies has great importance in the field of mathematics as in many other areas, in geometry classes as it provides an

important contribution to mathematics education by helping students develop their reasoning and mathematical problem solving skills. This is one of the aims of mathematics teaching as well as providing the skills to be used later in life. Problem solving instructional strategies provide mathematical problem solving skills that need to be taught in the curriculum and skills that one needed to succeed in solving mathematics problems as well as real world problems (Yuan, 2016). In addition, growing bodies of research suggest that problem solving instructional strategies in mathematics are powerful approaches in helping students develop higher order skills that improve their problem solving and fosters the development of a variety of strategies that support students' gradual shift to the use of more efficient retrieval and reasoning strategies. Ball (2005) described problem solving instructional strategies as basic in deepening students' mathematical problem solving skills (reasoning skills) in classification, recognition of relationship and use of counter examples to investigate conjunctures, construct and defend arguments. According to Jacobs, Martin, Ambrose and Philipp (2014) engaging children in a problem solving conversation goes beyond helping the children reach a correct answer, but helps them learn about their mathematical thinking skills that support their problem solving skills. Problem solving instructional strategies are critical and highly relevant for developing students mathematical problem solving skills and in providing students with decision making skills, skills for the analysis of problem situation and other necessary skills for solving mathematics problems as well as daily living problems. Problem solving instructional strategies are generally found to be effective in improving students skills for solving problems.

Protheroe (2007) opined that through meaningful problem solving instruction, students in the middle grades are able to think hypothetically, comprehend cause and effect, reason in both concrete and abstract terms which result to improved skills for problem solving. Also, Burris and Garton (2007) reported that when students were taught using problem-based instruction, their problem solving skills and critical thinking abilities increased.

Therefore, problem solving processes could be very useful in mathematics, science, social sciences and other subjects. It encourages students to develop and discover their own problem solving strategies and use them for problem solving. This helps them to develop their confidence in tackling problem solving tasks in any situation; enhance their reasoning skills and achievement (Aydogdu&Kesan, 2014) and as soon as the students develop and refine their own pattern of problem solving strategies, teachers can highlight or concentrate on a particular strategy, and discuss aspects and applications of the strategy. These develop students' flexibility to choose from the variety of strategies they have learned which eventually increases their learning outcome. Hins (2008) regard, problem solving instructional strategies generally as key component to teaching science and mathematics in particular. This could be that problem solving involve the application of suitable varied techniques or methods that guide students in selecting the most appropriate strategy from a variety of strategies for solving any given problem in mathematics. In other words problem solving as a strategy for teaching mathematics helps students in understanding the problem by being able to restate the problem in their

own language, identify the unknown variable and draw their plan for solution of the problem, execute the plan by following logical procedures and verify their result. It is expected that when students are able to do that successfully, their skills of solving problems would be enhanced.

### **SUMMARY**

The paper stresses the role of problem solving instructional strategies in enhancing student's mathematical skills. Where problem solving is considered as a step by step process that problem solver need to adopt and follows in solving any given mathematical problem. It is also described as a means of getting out of a difficulty or an obstacle through the selection and application of appropriate and less time consuming stages in solving problems. Similarly, students' mathematical skills form their reasoning and thinking abilities in solving problems in mathematics and other related areas. It is skills that are necessary for individuals and learners in particular to be able to achieve their set goals. In view of that, problem solving instructional strategies are fundamental in improving students' mathematical skills for solving mathematics problems as it provide them with a series of outline steps that can be applied and followed in solving mathematics problems and even problems of daily life. Therefore, students' problem solving instructional strategies should be developed by teachers to support their thinking and reasoning skills for better problem solving.

### **CONCLUSION**

Problem solving instructional strategies are procedures, process or step by step activity that is considered necessary for students as it increases their reasoning and thinking skills that support their mathematical skills. When students' mathematical skills are enhanced, it may lead to general improvement in mathematics achievement.

### **RECOMMENDATION**

It is recommended that learning organizations should use different problem solving instructional strategies with different steps to enable students improve their mathematical skills.

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