International Journal of Mathematics and Statistics Invention (IJMSI)
E-ISSN: 2321 – 4767 P-ISSN: 2321 - 4759
www.ijmsi.org Volume 10 Issue 5 || Sep.-Oct., 2022 || PP-01-06

Currents Trends in Improving Mathematics Education in Nigeria Secondary Schools: The Need for Problem Solving Methodologies

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Abstract
Teaching is a process of enabling pupils acquires knowledge and skills, in an interactive process that involves the teacher, student and the environment which helps in promoting learning through classroom activities. The teaching method that entails and encourages students' development of basic abilities, rational skills and personal qualities relate to problem solving teaching method that covers activities such as quizzes, puzzles, work cards, board games, sorting and inquiry. Against this backdrop, the paper examined the concept of problem solving teaching method and characteristics of problem solving methods. Furthermore, the paper discussed the need for problem solving methodologies in teaching mathematics and problem solving methods in teaching mathematics. It equally highlighted constructivism and problem solving method. Finally the paper recommended that mathematics teachers should be encouraged and motivated to use problem solving teaching method to facilitate teaching and learning as well as enhance students attitude and academic performance in mathematics.

Keywords: *problem solving method, mathematics education, constructivism, characteristics, inquiry*

Date of Submission: 01-10-2022 Date of Acceptance: 13-10-2022

I. Introduction

Teaching is a process of enabling pupils acquires knowledge and skills, in an interactive process that involves the teacher, student and the environment which helps in promoting learning through classroom activities. The teaching method that entails and encourages students' development of basic abilities, rational skills and personal qualities relate to problem solving teaching method. Problem solving method of teaching is a process to solve problems through higher order cognitive operations of visualizing, associating, abstracting, comprehending, manipulating, reasoning and analyzing. It encourages students to promote and construct methods through practice, and reflect to solve problems. The individualized, self-directed learning provides independence to the learner to decide about learning themselves under the guidance of teacher. The learning objective is not to receive the learning content without any active participation and reproducing it with memorization. It is dynamic and innovative engagement of students in group work and in individual study activities.

In problem solving teaching method, teachers must be clear about what they want in their students to achieve as they structure circumstances that are both challenging and achievable for a wide range of students. Teachers are required to be able to adopt instructional approaches and activities to encourage students' development of basic abilities, rational skills, and personal qualities. As Weber in Behlol, Akbar & Sehrish (2018) declares that the teacher must have a solid understanding on how to develop ability of arguments in students to solve a problem. Problem solving involves taking series of actions in the process of an investigation that seeks to bridge the gap between a problem state and the anticipated goal (Jackson (1993) in Babatunde, 2008). A problem-solving strategy therefore comprises action and steps taken by the learner to reach anticipated goal when faced with a problem situation. Problem solving means engaging in a task for which the solution method is not known in advance.

Furthermore, Behol, Akbar and Sehrish (2018), classified problem solving teaching method into a four-critical structures that involve engaging students in group work and in individual study activities. The following are the critical structures in engaging students as revealed by literature: values and ideas relevant to the content area, questions and ideas related to the problem of inquiry, teachers as facilitators for students to work out the solutions themselves and reliable remedy to the problem. Teachers' facilitation and students active participation consists of where the teacher initiates, guides and directs classroom talk with students. This talk is directed towards a specific target or problem. This talk pattern is a central focus of the problem-solving teaching method. In the problem solving teaching method the teacher illustrates teaching with instructional materials in the classroom that enables students to understand the problem, devise a plan and carry out the plan.

Concept of Problem Solving Method

Many teachers of mathematics have considered this method as being the act of solving mathematics problems on the chalk board. By this, they consider problem solving as a teacher-centered method of teaching. Contrary to this view, problem solving is a student-centred method. It is defined by Lester (1980) as a situation in which an individual or group of individuals is called upon to perform a task for which there is no ready accessible algorithms which determines completely the method of finding solution. By this definition, problem solving is similar to the pure inquiry, which involve perplex situation. This method is characterized by a question or situation accepted by the solver at the time it is presented when there is blockage or challenge so that the solution is not immediate. Thus Akers (1981) defined problem solving method as "what you do when you don't know what do".

An improvement on this method was suggested by Polya (1957) who outlined the following steps for problem solving:

i. Understand the problem
ii. Devise a plan
iii. Cary out the plan

To be successful in problem solving strategy, Schoenfeld (1985) suggested these mathematical behaviours as important.

- The solver's mathematical resources
- The solver's ability to use heuristics
- The solver's full control of the resources and heuristics
- The solver's belief about mathematics and himself to form the bases for his action.

According to Odili (2000), good problem solvers are distinguished from poorer ones not by how much they know but by how well they can apply what they know in unfamiliar context, quoting Hunt (1983).

Problem solving involves taking series of actions in the process of an investigation that seeks to bridge the gap between a problem state and the anticipated goal. A problem-solving strategy therefore comprises action steps taken by the learner to reach anticipated goal when faced with a problem situation. Problem solving means engaging in a task for which the solution method is not known in advance. Yewande (2000) was of the opinion that problem solving is using information and reasoning to overcome obstacle barrier.

Problem-solving is the highest form of learning (Klausmeier & Goodwin, 2017), since the individual defines new ideas based on this process. Likewise, it is well known that when faced with a problem one needs knowledge of rules, on the one hand, and the capacity to use them, on the other, thus achieving transfers of learning. Being able to solve problems, then, enables persons to their environment and to modify it in part. (Serrano, Cantu & Vila, 2003).

Teaching pupils to solve problems is based on the hypothesis that knowledge is organized and stored in memory in a sequential and logical networks (Anderson, 1992) and hence it can be retrieved in a stepwise and sequential manner to solve problems (Selvavatuan, 2003). This then means that for successful solution of a problem knowledge alone may not be sufficient. The Knowledge of how the conceptual knowledge should be applied (problem-solving skills) in solving problem is equally important. This form of knowledge is called the procedural knowledge (West, Framer & Wollif, 2016) on which the theory of problem-solving strategy is based.

Characteristics of Problem Solving Methods

Okoro (2019) has identified following characteristics of PSA:

1. Problem solving is interaction between teacher/students and vice versa.
2. The teacher helps pupils to understand and define problem clearly and he/she also endeavors to highlight importance of the problem at hand.
3. Teachers provide appropriate amount of knowledge to establish problem, and students understand, clarify, and make an attempt to formulate one or more solution procedures.
4. In a non-evaluative way teachers accept wrong/right answers.

5. Teachers need to be trained to ask perceptive questions, and play supervisory and as well as sharing role in the procedure of solving problems.
6. Teachers know when and where to step back or forward and how to let the pupils make their own way.
7. The PSA may improve problem solving skills of the students. If the students are provided opportunities to experience variety of problems besides choosing and implementing solutions, their abilities will definitely improve and they will be more likely to benefit from their problem solving ability in new situations.
8. Students may be taught to understand that there is not necessarily just a single answer to a particular question.
9. Children are often shy of speaking out and volunteering their own ideas. It is required by a teacher to facilitate and encourage students and also ask thought-provoking questions.
10. Teacher may show students how to approach a problem, formulate it and devise a strategy for its solution in addition to evaluating the problem and selecting the elements including a verbal analysis of the problem's parts which may lead them to solution.
11. In using the problem solving method, the subject matter must be organized on a basis of problem. The teacher must always be conscious of the practical value of this procedure. The material, such as references necessary for the solution of the problem, must be placed at the disposal of the pupils.
12. The teacher must bear in mind that only problems which stimulate thinking and reasoning are educative.
13. The problems should not be too broad in their scope. Many such problems make the pupils lose their interest long before a solution is reached at. In such a situation, the big problem should be divided into smaller and inter-related problems, and each small problem should be solved independently.
14. The principle of cause and effect should be emphasized while using this procedure. The development of reflective thinking is the fundamental aim of this method. The problem should involve both thinking and reasoning. Facts should be learned as part of the situation demanding reasoning and not for mere memorization purpose.

Need for Problem Solving Methodologies in Teaching Mathematics

Problem-solving as a teaching strategy has been used with degree of success in mathematics. According to Nafees (2011), problem solving is a process to solve problems through higher order cognitive operations of visualizing, associating, abstracting, comprehending, manipulating, reasoning and analyzing. Problem solving method encourages students to promote and construct methods through practice, and reflect to solve problems (Weber, 2008). It increases self-confidence in students to think mathematically for constructing, assessing and improving their own theoretical formulas and techniques to solve problems. Teachers must be clear about what they want in their students to achieve as they structure circumstances that are both challenging and achievable for a wide range of students.

Problem solving method needs student-centered learning environment in which a student is the central figure of the learning process. The individualized, self-directed learning provides independence to the learner to decide about learning themselves under the guidance of teacher. The learning objective is not to receive the learning content without any active participation and reproducing it with memorization. It is dynamic and innovative engagement of students in group work and in individual study activities (Tick, 2007). Stepien and Gallagher in Okoro (2019) have given four critical structures of problem solving method:

1. **Engagement:**The problem addresses real matters that attribute to the larger social back ground of the students' personal world and increases values and ideas relevant to the content area.
2. **Inquiry:** It is in need of investigation to describe and improve the questions and ideas related to the problem.
3. **Solution building:** In problem-based learning, teachers are the facilitators and solutions are worked out by the students themselves. Students take part in inquiry, observation and investigation of hypotheses. They generate conclusions that are reliable and take ownership of their solutions. Teachers promote learning by acting as models/ representative behaviors they want their students to adopt.
4. **Reflection:** Assessment offers a structure of reflection as a reliable remedy to the problem, the emphasis on the difficulty of both the subject-matter concepts within the problem and cognitive process, given to perform as standards for thinking.

Problem Solving Methods in teaching Mathematics

Inquiry Method of Teaching: The inquiry method is a teaching strategy whereby the teacher asks the students to formulate the problems, state the purpose, predict the result, identify procedures and to perform the investigation and the students learn from these activities. Inquiry method involves unstructured exploration in which a student, through his mental processes such as observing, measuring, classifying, analyzing, synthesizing and evaluating can draw general conclusions from data which he has gathered (Abdullahi, 2018). The fact that

this teaching approach essentially helps the students to establish the facts, determine relevant questions and develop ways to answer the questions, it is termed a heuristic method. Inquiry and discovery methods are rooted in heuristic teaching, activity and problem-solving which are major ingredients of modern science (Ajewole, 1997). They have a common characteristic of being student-centred as opposed to other methods that are teacher-centred. It is on this basis that the two methods may be used interchangeably. Inquiry is a true problem solving approach. The difference is in the degree of involvement. Inquiry is more involving and a stage beyond discovery. Both methods engage students in activities that will enable them find solution to their instructional problems, (Abukakar, 1999). Williams (1997) defined inquiry as "a systematic investigative performance ability thinking which incorporates unrestrained inductive thinking capabilities after a person has acquired a broad and critical knowledge of a particular subject matter through formal learning processes". The processes involved in inquiry are the same with those of scientific investigations. These include: defining and investigating the problem, formulating hypothesis, designing experiments, carrying out experiment, gathering data, drawing conclusions and generalization. The importance of inquiry teaching is to arrange the learning environment to facilitate student-centered instruction and giving sufficient guidance to ensure direction and success in discovering concepts and principles. In inquiry exercise the learner puts things together alone and becomes a discoverer. The teacher acts as a catalyst, rather than as a dispenser of information (Onimisi, 2002). Some of the ways a teacher can demonstrate inquiry in mathematics include to:

i. Set a problem that contain some inconsistencies. Example: find the 20^{th} and 21^{st} terms of the sequence 2,4,1,5,0,6, - 1,7,… To find the solution, the child would need to set out the sequence in two parts like this

ii. Ask questions that will enable the learners demonstrate or describe the sequence of procedure already known to them. Example: A money lender borrows at simple interest and lends at compound interest at the same rate per month.

iii. Ask questions that will expect the learners to use evidences as basis for stating relationship between variables.

Types of Inquiry Method

There are three main types of inquiry method of teaching (Gbamanja, 2012). These are guided inquiry, free inquiry and modified free inquiry methods.

1. The guided inquiry: In this method the teacher originates the problem to be solved. The teacher then closely guide the students towards the solutions of the problem through structured learning activities. In this case one may guide the learner to avoid wastage of materials, avoid breakages and not spoon feeding the learner with stereotyped procedures to arrive at a given solution. Hence, some educators (Gbamanja, 2012) advocate for free inquiry.
2. Free Inquiry: In the free inquiry method students identify or originate their own problems and carryout independent investigations on how to solve problem without the teachers' guidance. In this case students originate problems based on science concepts and principles taught to them in class and then plan procedures and materials needed to arrive at the answers. Free inquiry can lead to true discovery by the students and this develops genuine self concept in the learner. However to avoid the dangers and wastage involved in free inquiry many educators (Abukakar, 1999) advocate for modified freed inquiry.
3. Modified Free Inquiry: In this method, the teacher presents the problem and ask the students to solve it. They work out the investigative procedures of solving the problem in their own ways without the teachers' guidance. The teacher sets the stage in modified free inquiry and encourages the students to solve the problem in their own way. Modified free inquiry is very essential in biology teaching, so that the learner may not just "mess about" aimlessly especially where dangerous and poisonous chemicals are involved and expensive apparatus are to be used.

Models

A model is a simplified structuring of reality, which presents supposedly significant features or relationships in a generalized form (Haggett and Chirley, 2016). As scaled down versions of phenomena (whether structures or processes or events), models facilitate comprehension and comparison. They also encourage deeper inquiry and make teaching easier for the instructor and less tasking for the learners (Igbozurike, 2015).

Models, according to Faniran (2017), perform the following:

a. Enable some groups of phenomena to be visualized and comprehended, which could otherwise not be, either because of its magnitude or because of its complexity;

b. Provide a framework wherein information can be defined, collected, ordered, explained and communicated; and

c. Facilitate comparison of some remote phenomena with a more immediate and familiar one

Simulation and Games

A simulation represents an attempt to present some facts of reality in a convincing manner for purposes of explanation, manipulation and analysis (Kibel, 2012). A simulation model is governed by predetermined and consistent rules. Ola (2012) recognized two important features of simulations. These must be, firstly, a systematic selection of a few numbers of items of reality for explanation, manipulation and analysis; and secondly, the collapsing and/or expanding of the time scale. Ola also recognized two types of simulation, computer and gaming simulations. Computer simulation treats that part of the society being studied as a system of interacting variables which responds to some forces introduced from without. Gaming simulation on its own mirrors a set of organization in which strategies and tactics are given prominence. Thus, it is helpful to think of games as a subset of activities with special characteristics within the wider context of simulations (Hall, 2016).

Ola (2012) provided us with some recommended steps for the design of gaming simulation. These steps, which are very helpful, are here reproduced:

a. Define the situation to be simulated
b. Identify individuals or groups with their particular roles
c. Specify the initial resources available to players
d. Establish the type and range of transactions that may take place between places and the order of such transactions
e. Define how players will use their resources to achieve their objectives
f. Select definite issues to focus the simulation on
g. Isolate the players' roles, objectives and resources
h. Map out a plan, in subplots and series of events, for the simulation
i. Develop a win-lose criterion for the players.

Constructivism and Problem Solving Method

Constructivism is a theory of 'knowing' and a theory of 'coming to know (Fosnot, 2015). As such, its implication for instruction and understanding how learners construct meaning are profound. Constructivists vary greatly in their understanding, selection and interpretation of how to apply constructivism. Emphasizing upon the importance of the learner's active engagement during the learning process the learner constructs or generates meaning from his/her experiences rather than passively receiving knowledge from the teacher. Constructivist views shift the locus of knowledge from a source external to the learner to a place resident within the learner. That is, constructivists believe that knowledge is not freestanding and context independent. They hold that knowledge is personally constructed through an individual's interactions with his/her environment. Instruction can facilitate the process, but instruction does not result in the transfer of knowledge. Only the learner can build meaning and increase his/her knowledge through the learning process. The content domain may be pre-specified, however what the student chooses to learn cannot be predetermined. Learning should aspire to inform students in how to approach the problem solving process of how to think like a subject matter expert – actually, as a user of the data, rather than as a repository for the data.

Collaboration among learners is critical because it is important to recognize each learner's unique perspective and to support the social negotiation of meaning. The learner therefore deepens his/her understanding through interacting with others in the environment. Once again, the emphasis is on constructing meaning rather than acquiring and processing knowledge. The role of the teacher in a constructivist learning environment shifts from that of an authority figure to that of a mentor figure. Since knowledge is no longer transmitted from the teacher to the learner, and knowledge construction becomes the responsibility of the learner, the teacher therefore assumes the role of a learning facilitator. One way in which facilitation can occur is by modeling the use of tools in a manner similar to that, which exists in the relationship between a master and an apprentice (Winn, 1993).

II. Conclusions and Recommendations

In this paper a description and the critical features of problem solving method in-terms of understanding the problem, devise a plan and carrying out the plan were examined. In terms of its characteristics, problem solving method entails that there should be interaction between the teacher and students and vice versa as well as helping students to understand and define problem clearly. Moreover, the paper showed the need for problem solving methodologies in teaching mathematics and the relationship between constructivism and problem solving method in teaching and learning of mathematics. In this regard the following recommendations are made:

1. Mathematics teachers should be encouraged and motivated to use problem solving teaching method to facilitate teaching and learning as well as enhance students attitude and academic performance.

2. The curriculum of teacher education in mathematics in Nigeria should emphasize the use of problem solving teaching method to stimulate learners to be part of whatever concept that is presented to them.
3. In-service training, workshops and symposia should be organized and made compulsory for practicing teachers to embrace the skills of problem solving teaching method for effective implementation of mathematics curriculum.

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IYEKEKPOLOR, S.A.O.(PhD), et. al. "Currents Trends in Improving Mathematics Education in Nigeria Secondary Schools: The Need for Problem Solving Methodologies." *International Journal of Mathematics and Statistics Invention (IJMSI)*, vol. 10(05), 2022, pp. 01-06.