SciencePG
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Research Article

Methods and Strategies for Effective Teaching of Mathematics in Secondary Schools in Nigeria

Festus Sunday Smart Oloda[*] , **Solomon Gboyega Ojo** , **David Sunday Durojaiye**

Mathematical Sciences Education Programme, National Mathematical Centre, Abuja, Nigeria

Abstract

If the mathematics is to be interesting rather than a dull experience for the students, the first steps must be to make it a positive rather than negative emotional experience for the teachers. The importance placed on the subject is derived from the fact that it would help the nation meet its quest for science and technological advancement. A lot required from the mathematics teacher in terms of methods and strategies for effective teaching and learning of mathematics in secondary schools to meet the learning expectation of the students and other stake-holders. You need satisfied, competent and confident teacher to produce satisfied and confident students. The teacher is a major learning resource in mathematics at any level. If he is effective, he is catalyst, a stimulator, an inspirer and facilitator. He has to be able to facilitate learning by creating opportunities which enable learner to investigate situations. He has to have internalized techniques which enable him to go beyond ordinary routine questions ending at the knowledge level, comprehension, application, analysis, synthesis and evaluation which may together be called higher intellectual skills and abilities have to be viewed by the mathematics teacher as important attributes to be acquired by his students. Teaching process cannot be said to be complete if assessment of the students, teachers and the, methods and strategies employed are not thoroughly carried out, The teacher must know the best techniques and methods of presenting his ideas to the students putting into consideration students interest, needs, individual differences, difficulties and abilities. Thus, for effective teaching and learning of mathematics, a teacher must embrace active learning as against the traditional method of teaching mathematics.

Keywords

Method, Strategies, Effective Teaching, Mathematics, School

1. Introduction

Mathematics is a creation of the human mind concerned primarily with ideas, processes and reasoning [1]. According to [9] mathematics is much more than Arithmetic, the science of numbers and computation, more than geometry, the study of shapes, size and space. It is greater than numeric trigonometry which is the study of the relationship between sizes of any triangles and their angles. It is more than statistics, the science of collection, presentation, analysis and interpretation of data and graph, thus mathematics is one of the core subjects in both primary and secondary schools. According to [3] Mathematics is the bedrock upon which scientific Knowledge rests and hence, for a modern existence, amid rapid technological development, a good knowledge of Mathematics is inevitable. Mathematics is widely known to be the language of science and it is often called the mother of science. It is a tool for technological development hence no nation can grow technologically without a sound

mathematical base. Thus there is a need to provide a very solid foundation for it at both primary and secondary levels. It should be of note here that despite the importance of mathematics in all sphere of human endeavor, mathematics has become a subject dreaded by pupils and students from primary through secondary school levels even to the tertiary level.

One of the factors that contribute to the difficulties associated with mathematics in our schools is the various ways or methods by which mathematics teaching is being handled or presented by mathematics teachers; example of such method is the lecture style. This is the most common method of teaching used in mathematics; it is one direction method of teaching whereby students are not engaged during the period of teaching. Some mathematics teachers also have difficulties in teaching some perceived difficult concepts such as Latitude and Longitude, Probability, Constructions and Loci, Circle theorems and so on at the secondary school level.

For effective teaching of mathematics, the teacher is required to have adequate knowledge and background in the mathematical content, this in terms of being well equipped with the concept or idea of what he/she is going to teach. Mathematics teachers must like the subject Mathematics and this in turn will enable the students to have confidence in him. The pedagogy of teaching mathematics determines the level of students understanding of the concept. One of the qualities for successful teaching is good methodology. The teacher must know the best techniques and methods of presenting his ideas to the students putting into consideration, students' interest, needs, individual differences, difficulties and abilities.

2. Some Common Faults in the Teaching of Mathematics

Teachers are the main determinant of the quality of education system and for quality education in our society, we need excellent teachers. For the purpose of this paper, faults shall be viewed as unintentional mistakes, which if allowed to accumulate could have negative impact in the learning and mastery of the subject.

The following among others are some common faults which can lead to failure of a teacher in the classroom which in turn leads to students' failure in the subject

1. Lack of preparation – This is one of the causes of teacher's failure in the classroom. It can lead to unorganized, uncoordinated, non sequential and incoherent teaching exercise. This goes to buttress the popular saying that proper planning prevents poor performance.
2. Teaching rules and formulae – It is an error for a teacher to teach the students only rules and formulae of mathematics concepts without any explanation on how the formulae are derived. E.g Difference of two squares: $x^2 - y^2 = (x + y)(x - y)$
3. Wrong method of solving a problem – This is one of the causes of teacher's failure in the classroom. Proper

teaching method should be adopted according to the situation, learning environment and educational background of the students. Thus, emphasis must be focused on correct method of solving a given problem.
4. Lack of adequate/appropriate use of instructional materials – Some mathematics teachers teach mathematics concepts without the appropriate and suitable instructional materials.
5. Attempting more than necessary in a lesson – Teaching a topic that is meant for a week (four periods) in just a period is a fault.
6. Lack of interest on the part of the teacher – Teacher's interest in the teaching of mathematics is a source of inspiration and motivation to his students.
7. Mode of Assessment - It is important to look into the mode of assessment in schools. Most teachers construct test without test blue print otherwise known as table of specification and all necessary procedures of test constructions are not followed. Thus, making our tests invalid, unreliable and unusable.
8. Solving problems for student – some teachers are in the habit of solving any problem brought by the students rather than encouraging students to come along with their solution when they are unable to solve any item in the textbook exercises. This would enable the teacher to identify the problem of the student regarding the item and the topic.
9. Inflation of Continuous Assessment scores (CA) - The general practice in schools is the inflation of continuous assessment scores which is always counterproductive in the final grade or score. This is not unconnected with the fact that the examination body moderates the C/A thus, giving a negative correlation thereby pooling down the final scores or grades of the students.

3. Methods of Teaching

Effective teaching involves all activities which would help to inspire the students to learn and create ideas. [8] opined that the success of teaching depends on the method of teaching adopted by the teacher. There are various types of teaching methods in schools (Basic to Secondary Schools) since the shift from the inherited system of education in Nigeria after the Nigeria independence in 1960. Over the years, researchers and educators have been varying methods of teaching so as to find the best method of achieving effective teaching in the classroom. There is no one "right" method for teaching a particular concept in mathematics. Obviously, not all methods are appropriate for all levels and content areas. An instructional method comprises the principles and methods used for instruction. Commonly used teaching methods in mathematics includes but not limited to: lecture method, inductive method, deductive method, discovery method, laboratory and problem solving method.

3.1. Lecture Method

In this method, the teacher delivers knowledge through talk and chalk. This is the oldest method and it is often referred to as the traditional method and it is called teacher centered approach because the teacher is an active participant while the students listen and writing the key points in their notebooks. In literature, this method has been proved to be counterproductive due to the fact that it makes students passive during teaching and learning process which in turn encourages memorization of mathematical concepts with little or no understanding of the concepts memorized. Thus, it does not develop reasoning and thinking ability in the students. Also, due to lack of activity the lecture becomes boring. However, there are some advantages of lecture method they include but not limited to:

1. It is the most convenient and easy method
2. It becomes useful when the strength of a class is very high
3. It is very useful for the introduction of new concepts
4. It is more economical due to lack of instructional materials to be used during learning process
5. It is relatively more useful in tertiary institutions

3.2. Inductive Method

Inductive method also known as scientific method involves leading from known to unknown, from concrete to abstract from particular to general and from example to formula or rule. This method is based on induction thus, Students are presented with sufficient number of concrete examples or problem related to a specific domain. Then, they are to construct a formula or rule by observing them which means proving a universal truth by showing that if a generalized result is true for a specific example or problem and is further true for a reasonable adequate number of cases then it would also be true for all kind of cases.

According to sekhar as cited in [5] inductive method is useful in the introduction of a new mathematical concept along with a rule or formula, it is very logical and it aids students understanding of mathematical concept. Students play an active role in this approach thus; it is called students centered approach. It motivates students to think logically and make learning environment to be more interesting. Students easily remember the rules or formuli which they construct by themselves since the process is based on reasoning and experimentation. However the method is time consuming and laborious, it does not develop problem solving ability in students.

3.3. Deductive Method

This method is in variance with the inductive method. This method involves the learner to proceed from abstract to concrete, general to specific and from formula to example. Here, learners are taught already constructed formula or rule for mathematical concept by the teacher and learners are asked to apply them to

solve related mathematical concept by the teacher and learners are asked to apply them to solve related mathematical problem. This method enhances accuracy and efficiency in solving problems. According to [5], this method is a blessing for those learners who cannot remember complicated rules or procedures. It saves time thus enable teachers to complete the syllabus and it enhances the computational skills of learners. However, the method makes learners to be passive during teaching and does not help in the improvement of reasoning ability of the learners. The method can only be useful at the higher level of learning but not be effective at the lower levels.

3.4. Discovery Method

The discovery method also known as Heuristic method is used to overcome the shortcomings attributed to the lecture method which is widely known to be teacher centered. In this method, the learner is guided by the teacher to derive mathematical formula through activities and observations during the activities. This method is a student centered approach, it makes learners to develop self-reliance, and scientific attitude in learning. Also it increases the reasoning and thinking ability of the learners. However this method is a time consuming thus, it requires teachers to be properly trained before the application of the method in the classroom. Also, the method is only suitable for the teaching of some mathematics concepts.

3.5. Laboratory Method

The major part of learning of mathematics is practical work. Thus, the subject mathematics is not expected to be learnt by reading. This method is "learning by doing" Learners are exposed to various tools and equipments for the performance of practical work in the teaching and learning of some mathematical concepts. Such as charts, graphs, shapes, areas, volumes and so on. Experiments are also carried out in the laboratory or classrooms such as Tossing of coins, throwing of dice, shuffle of playing cards, relationship between volumes of cylinder, cone and sphere with same properties and so on. The role of a teacher in this method is to supervise the whole process and give proper instructions to the students at each step. This method is student centered and students develop confidence in mathematics when they establish formula by themselves. This method is time consuming thus, it requires teachers to be properly trained before the application of the method in the classroom. A mathematics laboratory in secondary schools is required for effective teaching and learning of some mathematics concepts.

4. Strategies for Effective Teaching

For effective teaching of mathematics, the teacher is required to have adequate knowledge and background in the mathematical content, this in terms of being well equipped with the concept or idea of what he/she is going to teach.

Mathematics teachers must like the subject (mathematics) and this in turn will enable the students to have confidence in him.

The pedagogy of teaching mathematics determines the level of students understanding of the concept. One of the qualities for successful teaching is good methodology. The teacher must know the best techniques and methods of presenting his ideas to the students putting into consideration, students' interest, needs, individual differences, difficulties and abilities. It has been observed in literature that much of the recent research on effective teaching of mathematics focuses on instruction that promotes students involvement and activity base. Thus, the pedagogy of teaching requires teachers to embrace active learning as against the traditional method of teaching mathematics.

In light of the above, the following strategies should be integrated to the teaching of mathematics in schools:

4.1. Practical Teaching of Mathematics Concepts

Practical involvement of students in the teaching and learning of mathematics concepts and ideas with the aid of instructional materials helps both teachers and students to achieve the stated objectives of the lesson e.g Probability (Tossing of coins, throwing of dice, pack of playing cards), Construction and Loci, and concrete objects that the students are familiar with most especially in the junior classes. In general the teacher involves the students during the period of teaching. This is student's active base teaching and learning. Activities and practical experiences are vehicles through which the teacher leads his students in pursuit of the achievement of a given objective in mathematics [11]. According to [6], Practical work should involve all the students in the class, he opined that until students are allowed to do things for themselves, rather than sitting in tidy rows while the teacher "tells" them how to solve their equations, this will not be easy.

4.2. Adoption of Discovery Method of Teaching

This is a strategy where the learner is guided by the teacher to derive mathematical formulae through activities and observations during the activities. Put differently the teacher aids the students to find out some concepts in mathematics, this could be done by grouping the students to perform given activities or by individual activities e.g Area of rectangle, Area of a circle, Pythagoras Rule, Difference of two squares, Introduction of Locus (Loci), and so on could be taught by teachers through discovery method, this would enhance students' participation in the mathematics classroom.

4.3. Effective Use of Instructional Materials

Instructional materials otherwise known as teaching aids help to demystify the mysteries of mathematics and help to concretize the concepts learnt during mathematics class. Thus, instructional materials help to arouse the interest of students in mathematics which in turn sustains the interest of students if properly utilized during teaching. According to [4, 10], the use of instructional materials can stimulate both visual and auditory stimuli, especially in large classrooms or auditorium where modern technology can be used to control the size of the visual image and the amplitude of the sound that the students can hear/see.

4.4. Variety of Teaching Methods

Teaching of mathematics in schools is often formula base, thus varying the teaching methods will prevent the lesson from becoming boring, monotonous and the students will be engaged. For instance, teaching of *Factorization of quadratic expression*: - Representing quadratic expression by the area of a rectangle where the factors are represented by the length and breadth of the rectangle or by area of squares if the quadratic expressions are perfect squares/factorizable.

4.5. Generating Student's Interest

Since mathematics is a subject dreaded by students, teachers should try as much as possible to generate students' interest while teaching. According to [9, 6] the following could go a long way in generating students interest in mathematics.

a) The use of instructional materials and practical involvement of students will go a long way to arousing students' interest e.g Teaching of: Angle of elevation and Depression by the use of Clinometers, Pythagoras theorem by drawing the square units of each side of a given right angled triangle, Area of a rectangle by drawing and counting the number of squares unitsin the given plane shape and so on.

b) Formation of Mathematics Club: This can be an avenue for rubbing minds together on problems of common interest. The Mathematics club plays important role in creating interest in mathematics in school. This helps students in having an idea of the practical utility of mathematics in addition to creating their interest in mathematics. mathematics club is useful in arousing and maintaining interest in mathematics [10]. The student gets an opportunity of mathematical hobbies, recreational mathematics, mathematical discussions, debates and mathematical innovations. It provides an opportunities for leadership, co-operation, joint responsibly, active participation and organizing programmes.

c) Students Motivation:

1) Student should be motivated when a question is answered correctly and if otherwise the student should not be boo or castigated with abusive words. Words of encouragement should be used lavishly by the teacher instead of flogging, scolding or abusing.

Some discouraging words like, "you, big head", "do you think mathematics is for people like you?" should be avoided in mathematics lesson.

2) Recognition of good students: Good students in mathematics could be decorated with badges or emblems for others to emulate. Recognition of students enable teacher to know how to tackle students misconception and error, present approaches to overcome the misconceptions, predict student thoughts and possible solutions, and encourages them to provide different solutions [2]. Knowing good students will enable the teacher to inspire the students to mathematics success, energize the students for achievement, liberate the student from career limitations, free the students from mathematical fear and enable the student's dream come true.

5. Mode of Assessment

In order to achieve a vibrant result in mathematics achievement tests in schools, it is important to look into the mode of assessment in our schools. Assessment, testing and evaluation techniques of the students leave much to be desired. A teacher who constructs a test without test blue print is just like a bricklayer building a house without a building plan. Most teachers construct tests without blue print and all the necessary procedures of test constructions are not followed. Thus, making school based tests invalid, unreliable and unusable. The internal examinations are called Teacher Made Test (TMT) while the external examinations on the other hand are called Standardized Test and they are valid, reliable, and usable. In order to make the TMT reliable and usable, the process of transformation of raw scores must be followed i.e the Z-score and T – score.

Test Blue Print (Table of Specification) - Test is an instrument used to elicit a sample of behavior from which the general behavior is inferred. [7] defined test as an instrument used to measure a systematic sample of an aspect of behavior from which a total aspect of behavior is inferred.

Test Blue Print is a two-grid chart that matches the content objectives with the process objectives. It can also be defined as a plan prepared by a classroom teacher as a basis for test construction such as periodic test.

Test blue print can also be defined as a two-grid chart which describes the topic to be covered by a test and the number of items which will be associated with each topic. The following are the importance of Test Blue Print:

1) It serves as a guide for writing test items.
2) It enables the teacher to prepare a test containing a good representative sample of student behavior in each of the area tested.
3) It ensures proper emphasis given to all elements of the content.
4) It gives content validity of the test.

The following are to be noted when building Test Blue Print
1) Content objectives and Process objectives
2) Topic covered in class
3) Amount of time spent on each topic
4) Number of test items in the test
5) Classification by format – Essay, Objectives: types

Table 1. Test Blue Print (Table Of Specification).

Content Objectives	Process Objectives					
	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation

The allocation of items into cell in any test blue print is based on the law of proportion ie the items (questions) will be shared in the ratio of duration of periods used to teach each of the topics. For example, suppose the following mathematics topics are thought according to the scheme of work for a particular term in a school.

Table 2. Mathematics Topics.

S/N	TOPIC	NO OF WEEKS
1	Fractions	1
2	Inequalities	3
3	Mensuration	4
4	Constructions	2
	Total	10

Suppose we wish to set (A) 50 objective items and (B) 5 Essay items.

NOTE: Share the topics into ratio 1:3:4:2

A. Topic	Duration	No of items
Fractions	1	$\frac{1}{10} \times 50 = 5$
Inequality	3	$\frac{3}{10} \times 50 = 15$
Mensuration	4	$\frac{4}{10} \times 50 = 20$
Constructions	2	$\frac{2}{10} \times 50 = 10$
Total items		50

A. Topic	Duration	No of items
Fractions	1	$\frac{1}{10} \times 5 = \frac{1}{2}$
Inequality	3	$\frac{3}{10} \times 5 = 1\frac{1}{2}$
Mensuration	4	$\frac{4}{10} \times 5 = 2$
Constructions	2	$\frac{2}{10} \times 5 = 1$
Total items		5

Figure 1. Allocation of items.

It is advisable to construct more items in each cell so that after trial test some items (questions) will be sieved out in order to ensure content validity ie the degree of coverage and the degree of representation.

6. Test Scores /Marks

Test is an instrument used to elicit a sample of behaviour from which the general behaviour is inferred. Test scores and marks is the numerical value that reveals the performance of students in a given test. Test score can also be defined mark/score as numerical value of students performance in a given test or examination. Test scores includes but not limited to the following:

1) Raw score
2) Percentage
3) Rank
4) Standard score
5) T – Score

a) Raw score - This is the number of correct responses given by a testee in a given test or examination. The major weakness of raw scores is that it lacks the ability to compare scores of different subjects or scores of testees in the same subject at different periods.

b) Percentage score – This is when a score is scaled on 100 equal parts. It is the conventional mode of scoring in West Africa.

c) Rank – This is the distribution of positions from the highest to lowest.

d) Standard Score (Z – Score) – This is the conversion of raw score into a scale. This enables the scores of students to be compared in a system of reporting. A standard score is produced when the distance of a score from the mean of the distribution is divided by the standard deviation of the distribution.

$$\text{Standard Score (Z-score)} = \frac{X - \bar{X}}{SD}$$

Where - X = Raw Score
$\bar{X}$ = Mean Score
SD = Standard Deviation
T- score – This is the sum of 50 and ten multiply by Standard Score (z)

$$T - score = 50 + 10Z = 50 + 10\left(\frac{X - \bar{X}}{SD}\right)$$

For example, suppose the mean of a Test = 35, its standard deviation = 5. Compute the (a) Z-Score and (b) T-Score of a raw score of (i) 45, (ii) 30.
Solution

$$(a) \quad \text{Z-score)} = \frac{X - \bar{X}}{SD}$$

Mean $\bar{X}$ = 35, Standard Deviation = 5
(i) X = 45
Z-score $= \frac{45 - 35}{5} = \frac{10}{5} = 2$
(ii) X = 30
Z-score $= \frac{30 - 35}{5} = \frac{-5}{5} = -1$

$$(b) \quad T - score = 50 + 10Z$$

(i) T – score = 50 + 10Z
= 50 + 10 (2)
= 50 + 20
= 70
(ii) T – score = 50 + 10Z
= 50 + 10 (-1)
= 50 - 10
= 40

The two scores can be compared with the T- scores.

7. Conclusion

The position of mathematics among the school subjects is very central because it is a compulsory subject and, hence, must be effectively taught using potent methods and strategies that can deliver and enhance learning comprehensively. Teaching process cannot be said to be complete if assement of the students, teachers and the methods and strtegies employed are not thouroughly carried out. The paper therefore recommended that mathematics teachers are to be encouraged to have very good grasps of all the methods and strategies for effective teaching of the subject. Also, mathematics teachers should endavour to combine different methods when teaching mathematics because no one method is the best for teaching mathematics, but the combination of different methods will bring about effective teaching.

8. Recommendation for Further Research

Experimental researches should be carried out by other researchers on each of the methods and strategies discussed on the effective teaching of mathematics in secondary school.

Abbreviations

SD	Standard Deviation
TMT	Teachers Made Test
Z-Score	Standard Score

Conflicts of Interest

The authors declare no conflicts of interest.

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