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EFFECTIVE LEARNING OF MATHEMATICS: FROM THEORY TO PRACTICE

TSAFE, A. K.

Abstract

It was generally believed that, in the art of teaching regardless of discipline or level of operation of the learner, knowledge can best be imparted subject to some prerequisite features to be acquired by both encoders (teachers) and decoders (learners) in what psychologist called delivery and reception theory. For instance, the teacher has to undergo a prescribed training to be acquainted with the knowledge; likewise, the learner has to be ready and capable of receiving the information that may be given to him by the teacher. This may possibly serve as the basis through which students can best learn and understand Mathematics. In this regard, this paper explores what could be termed as an approach suitable for making students of Mathematics best learn Mathematics and offers a conceptual framework of the reasons why student faces challenges associated with Mathematics learning. The paper also contains the contributions of some notable psychologists on how best Mathematics could be taught to students at various stages of development. This ranges from Piagetians stages, Brunner and Gagne.

Introduction

The understanding and learning of Mathematics is viewed by its learners as surrounded by quite a number of things without which the learning could hardly take place on students' part and the teaching would equally be made untenable on the teachers' part. The perplexities emanating from these problems are quite tantalizing. In fact, it has attracted the attention of stakeholders in the field to establish and ascertain what might have led to these problems. This stimulated too many researches, all in an attempt to find lasting solutions to the problem.

However, the circumstances that led students to best learn or otherwise of Mathematics could be attributed to a number of things which range from the system, curriculum, teachers' teaching techniques (Methodology/Pedagogy), student's

attitude, gender differences, the emergence of computer, social networks and age among others. These things variously affect how *students best learn Mathematics.* Taking the system as an instance, Nigerian system of education has not made a concrete provision that would have been the reason why students learn Mathematics with enthusiasm. Unlike what is obtainable in the past when all the things capable of making learning of students attainable were provided; that students at that time could only be seen to be thinking of their studies and by the end emerge victorious and with flying colours but now hardly you come across a Nigerian student who is not having one problem or the other which ranges from economic, security and other personal needs which are capable of making him/her sound and therefore understand better when they are taught in the class. For somebody to be pre-occupied with such problems, he/she could hardly understand what is happening in the classroom especially when it has to do with Mathematics which was believed to be a concept portraying abstraction

Furthermore, researches conducted on various occasions revealed so many findings suggesting how best students can learn Mathematics if and only if the recommendations made by the researchers are properly implemented, failure of which the problem would only be compounded. In his recommendation, Korau (2010) said only qualified teachers should be employed to teach Mathematics using several strategies and methods that can enable students to understand what is being taught. This further attests to the above assertion that teachers constitute part of the reasons why students learn Mathematics. Similar to this was another contribution; that there should be inward looking into the production of text materials on Mathematics that would make use of the locally available resources to enhance its teaching and learning at all levels of the nations' education system. By this manner, the extent to which the foreign dominated analysis of concepts, which often makes the subject dreadful to the students would be minimized if not eradicated (Adetunji, 2007)

How do Students best learn Mathematics?

As inevitable as Mathematics is now in the 21st century, students at all levels of learning are faced with challenges because their chosen area/field of endeavour has to do with Mathematics. These range from Sciences, Technology, Medical Sciences, Social Sciences, Environmental Sciences, Astronomy, Arts and Humanities. This leading

role played or assumed by Mathematics made it all encompassing and attracted various names from experts. In this regard, Ali (1994) stressed that Mathematics is indispensable because it has substantial use in all other human activities including school subjects. This feature held by Mathematics is what makes it a-must-study subject right from primary through secondary and up to tertiary institutions. Therefore, for this paper to explore how student can best learn Mathematics, it focuses attention on the following areas

1. Teacher
2. Teaching Techniques (Methodology/Pedagogy)
3. Curriculum
4. Students' Attitudes
5. Gender Differences
6. Computer

Teacher

When looking at the level of the teacher interaction with student, teacher plays a central role when it comes to the issue of students learning a particular concept. Therefore, student can best learn through their teachers if certain conditions are met by the teachers. As a teacher, it is assumed that he/she must have undergone a prescribed training which put him/her ahead of his students. As such, whenever he/she appears in the classroom in the name of teaching, the students shall expect to interact with someone who is ahead of them in terms of knowledge. The level of teachers' attainment in education has an effect on how best student can learn a particular Mathematical problem. This is because certain teachers do not have adequate knowledge to take their students through some mathematical problems. If a teacher does not understand a given problem in Mathematics, he/she could hardly impart it to the students. This problem stemmed from the inability of Mathematics teachers to further their studies

Similarly, Kankia (2005) recommended that teachers should further their studies and attend seminars, workshops and conferences. This is to enable them to update their knowledge so that they would learn how to make their students learn Mathematics best. Meanwhile, in some instances mastery of the subject matter could be attributed to educational attainment. A teacher having a Diploma as his/her teaching qualification cannot be compared to the one with NCE and the one with NCE cannot be compared with a University graduate and on it goes up

to the highest qualification. As such, the more the teacher further his/her studies, the more chance the student has in understanding what he/she would teach them. That is what makes it necessary for teachers at all levels to crave for the sponsorship to go for an in-service training with the aim of advancing their knowledge from its current position to new level.

Teaching Techniques (Methodology/Pedagogy)

Even if the teacher would attain the highest educational qualification, what would complement his/her stand as a teacher is his/her ability to deliver while in the classroom. For this to occur, the teacher must understand who his students are, knowing their level of operation and their psychological readiness to understand what they would be taught. The method most often adopted by teachers in the classroom determines the extent of how best student can understand the lesson. It is the method employed in teaching that in turn makes the student to swiftly grab the message and understands it better. As unique as Mathematics, certain techniques and pedagogical skills applicable in other disciplines cannot be applied in Mathematics if virtually the target is to ensure how student can best learn Mathematics. This is what would ensure that the contents and learning experiences set to be achieved are well articulated and made easy for student to attain. It is of paramount importance for students as well as the teachers themselves if the contents are adequately arranged and simplified to such an extent that the perception of student as to the abstraction of Mathematics is properly taken care of.

To make the understanding of Mathematics possible, emphasis has always been made on a technique/method of teaching to use that is capable of enriching the process and make it sound and convincing to the learner through clarity of language, precision, accurateness and brevity among others. This is because Mathematics is the only subject in which one can score the whole marks and likewise fail the whole marks; so if the method and strategy used in the process is not such that it enables the learner to grasp the message, the entire process would appear to the learner as a kind of bizarre situation and end up confusing instead of assisting him/her in understanding the concept. There were a lot of strategies and techniques that have been developed by scholars and some were even used and have been proved to be successful when it comes to teaching mathematics. The techniques are problem-solving-

based and as such directly address the learners' problem in comprehending the message of Mathematics. Some of these techniques emanated from theories; these theories are mostly psychologically-based because they emphasized much on understanding the learners' needs and weaknesses before even thinking of the strategy to use in teaching him/her. The strategies and techniques that are expected of every teacher for him to make his students learn Mathematics best include among others discovery method, expository method, problem solving in addition to proper communication skills. These various strategies and methods if well understood by the teacher and properly applied enhance the level at which student learns a particular concept best. To begin with, discovery method for instance allows for students to identify knowledge, facts and ideas by themselves under the auspices of the teacher. This is what eventually led to the establishment of Brunner's theory of discovery learning where he advocated the teaching of the structure of the subject which follows some stages as outlined by Brunner to be *Enactive, Iconic and Symbolic*. This method if properly applied encourages full participation by students and their involvement and the arousal of their interest more than teacher-dominated method. Teacher can equally employ *Trial and Error* as a strategy in which the probability of students making a mistake is high which may be corrected eventually before making the discovery and stimulates students thinking by asking open-ended questions. Frequent question and answer could as well be used by teacher to make his students learn Mathematics the best way in what is termed as expository method of teaching Mathematics.

Above all in teachers' strategy to be adopted is his communication ability to the students. Mathematics teachers must possess adequate communication skills required for successful teaching and learning of Mathematics; which involves the ability of the teacher to deliver the subject with simplicity of language, easy to understand presentation, appropriate and effective teaching aids, a stimulating interactive environment and a display of the mastery of the subject matter (Korau & Popoola, 2010). When such strategies as outlined above are strictly adhered to by Mathematics teachers, no matter the abstraction of a particular concept, it could be well imparted to the students and the students can instantly grab the clear picture of the concept. In addition to making the students understand Mathematics very well, it was

observed that teachers who provide good classroom conditions, good teacher-student relationship and apply good classroom conditions will improve the academic achievement of students, thereby motivating them to score high marks (Timothy, 1991).

However, it is again part of the techniques and pedagogy which shall be used by teachers of Mathematics as advocated by Psychologist as mentioned earlier on. Such Psychologist includes *Jean Piaget, Jerome S. Brunner, Robert Gagne, Dianes and Ausubel.* These eminent Psychologists made a tremendous contribution on how best students can be taught in Mathematics. The contribution of anyone of them is independent and unique to one another as would be seen below:

Jean Piaget

Even though he was trained as a Biologist, Piaget was known to have made tremendous contributions on how best Mathematics could be learnt. The work of Piaget has greatest significance for Mathematics teachers especially at the primary school level which is the basis. His theories applied to the children general intellectual development and specifically to the development of mathematical concept. Piaget viewed cognitive development in terms of well defined sequential steps in which a child's ability to succeed is determined by his biological readiness for the stages and partly by his experiences with activity and problems in earlier stages. The stages as outlined by Piaget are:

- *The Pre-operational Stage (2-7years):* This stage generally covers the cognitive development of children during early primary school years and is marked by the ability to deal with reality in symbolic ways. The thought of children in this stage is limited to ***CENTERING*** (inability to consider more than one characteristics of an object at a time). Children at this stage also have difficulty with reversibility (the ability to think back to the causes of events), whereby because of these deficiencies, they cannot conserve (retain) important characteristics of objects and events, and cannot engage in logical thinking in any concrete sense. At this level, the child is said not to possess the concept of conservation of number, volume quantity or space. The implication for the Mathematics teacher at this stage is that, it is a waste of time and possibly harmful to children or learners to try to tell them things that cannot be experienced through their senses i.e. through

seeing, feeling as well as hearing. Children (learners) at this stage must be permitted to manipulate object and symbols so as to be able to appreciate reality.

- *The concrete operational Stage (7-12years):* This stage of child development is particularly important to primary school teachers because most primary school children are operating within this level. This stage marks the beginning of what is called logico-mathematical aspect of experience. Piaget studied the concrete operation stage using the concept of conservation of invariance which is the basic characteristics in this stage. This was done when initially a child is shown two identical glasses containing the same amount of water; after which the water in one of the glass would be poured in a taller glass whose diameter is different from the previous one. If the child understands the amount of water to be the same no matter the nature of the glass container or it somehow looks to him as if it contains more water, he is said to be using logic and has arrived at the concrete operation thought level for his concept. The amount of water is conserved and remains invariant (unchanged) after the transfer into another glass. This is referred to as the concept of conservation of invariance. The child at this stage realizes that the process can be reversed i.e. if the water is poured back into the initial glass, the amount should remain the same. The concrete operational stage is therefore important for Mathematics learning because many of the operations a child is carrying out at this stage are mathematical in nature.

- *The formal operation stage (12years-adolescent):* Children at this stage can reason abstractly if they are not affected by the limitation of previous stage. At this level, the child now reasons, hypothesizes with symbols or ideas rather than needing objects in the physical world as a basis for his thinking. In this regard, for teacher to be effective in classroom while teaching Mathematics, he has to take each and every stage into account and apply the provisions made so as to avoid encountering problem in the forthcoming stages. This is because Mathematics is a course whose level of abstraction is increasing with increase in the learners' level of operation. As such, it is of great importance for Mathematics teachers to make use of this approach judiciously

in taking their learners through some mathematical concepts

Jerome S. Brunner

In his contribution on how best Mathematics could be learnt, Brunner was able to claim that learning in general is dependent on four factors:

- The structure of the concept that is to be learnt
- The nature of the learners intuition
- The desire of the learner to learn
- The readiness for learning (biological readiness)

In this regard, Brunner considered adequacy of birth, the subject matter and the learner himself necessary for the learning of Mathematics. By this, Brunner means that the learner must be intuitively ready to learn and the materials to be learnt must be presented in a form (or structure) that matches the learners' readiness stage. The stages as claimed by Brunner where each child has to pass through in cognitive learning which has a direct bearing in Mathematics teaching are:

- *The Enactive stage:* At this stage, the child thinks only in terms of action. The child also enjoys touching and manipulating objects as teaching proceeds. A child or learner can be introduced to concrete objects but no serious learning occurs at this stage. The Child's methods of solving problems are limited because he cannot come up with the solution.
- *The Iconic stage:* This is the stage of manipulation of images. Learning here occurs through using models and pictures in the form of seeing which transform into learning. The child uses thinking thereby making transfer of learning considerably easy. Brunner emphasized that before any image is formed to represent a sequence of acts, certain amount of motor skills and practice has to take place
- *The symbolic stage:* At this stage, the child possesses the ability to evaluate learning. Logic, language and mathematical symbols are used to discuss what has been learnt. It describes the capacity to think in abstract form. Acquired experiences in the previous stages are translated into symbolic form

Meanwhile, Brunner like Piaget believed that all Mathematics could be learnt by discovery approach provided the search is started early

enough in the life of the child by presenting to him concrete materials relevant to the concept he should be made to learn at high level. For instance, proportion of a triangle could be taught to a child right from pre-primary school by making sure he plays with triangular-shaped objects. By junior secondary school, he would have been sufficiently equipped with various terms to discover for him some, if not all the properties of triangle. These approaches if well adhered to by the teachers; students would find it very simple and easy to understand Mathematics best.

Robert Gagne

Gagne devoted his time to study the conditions of learning. He believes learning occurs as a result of interaction between the learner and the environment. Learning according to Gagne is said to have taken place when we notice (observe) that the learners' behaviour or performance has been modified (altered). Gagne emphasized the idea of prerequisite knowledge in learning Mathematics; that is the idea that one cannot master complex concepts without mastering the fundamental concepts necessary for such complex concepts. For instance, the child cannot successfully add fractions without the knowledge of finding common denominator of fractions

Curriculum

Curriculum entails a conglomeration of whatever is to be taught to the students. As such, it plays a central role in helping students to best learn or otherwise of the contents of a particular course, subject or segment of instruction. Curriculum enables teachers to carefully make a plan on how best to teach their learners. But Nigerian Mathematics curriculum because of the transformation and changes it had over the years, which had profound impact on students, a lot of things has either been removed or added in it on various occasions. These changes and alterations in the content of Mathematics curriculum significantly affect how best students can learn Mathematics. However, it has its own advantage as well as the disadvantage. For instance, pre-independence curriculum whose aim then was to produce people with little knowledge on arithmetic needs not to be rigorous in its content. Meanwhile, subsequent curriculum that were variously developed for Mathematics contributed in no small measure as to whether students have actually been subjected to best ways of learning Mathematics or otherwise. The history of curriculum development on Mathematics in Nigeria have not been stable over the years as a result of which, whenever there are some new changes, students must equally have to make some

mental adjustments in order to accommodate such changes. A provision has to be made in the curriculum in such a way that whenever there is an alteration in the content of the curriculum, the teachers under whose guidance such changes and alterations would be taught to students are allowed to go for other scholarly activities like refresher courses, Mathematical conferences and workshops which would enable them to complement other things not provided in the curriculum and that are capable of making student understand the subject better. Teachers should equally become part of the professional bodies like MAN (Mathematical Association of Nigeria) and STAN (Science Teachers Association of Nigeria) so that they would be exposed to current issues especially how best to solve some particular problems in the subject. Subscription to both online and offline or hard written journals and Mathematical Magazines which would provide the teacher with Mathematical riddles, puzzles, fallacies, paradoxes, anecdotes and other enrichment materials all aimed at making students understand Mathematics the best way.

Students' Attitudes

Students attitudes have also been described as one of the reasons why they can learn Mathematics the best way. Interest plays a critical role in determining individual chance of learning Mathematics. Some individuals who could not learn as well, is because of their interest and level of commitments. Students tend to exhibit a number of attitudes which directly or indirectly affect their chances of learning Mathematics the best way. One of such attitudes as pointed out by Fasasi (2007) in a study conducted in some selected secondary schools in Adamawa State where he found out that there is a relationship between phobia in Mathematics and students' attitudes. Mathematics phobia to greater extent affects students in the learning of Mathematics. It is however a persistent, illogical, intense fear of not succeeding in Mathematics (Denny, 2004). It is believed that individual cannot handle the difficulty associated with Mathematics. Everybody is born with equal chance of learning through the judicious use of his/her learning senses but along the line some developed negative attitude and personal self concept which at the end leads them to despair as far as learning of Mathematics is concerned. Adebayo (2001) opined that students' negative attitude;

students' low self concept and poor pedagogical skills among Mathematics teachers are the causes of poor performances in Mathematics. By implication students play a greater role in an attempt to learn Mathematics by displaying their extent of interest.

Gender Differences

Some scholars in their research findings attributed the learning of Mathematics in some instances to be gender-inclined. This is when male students are considered to achieve more in Mathematical Sciences and female students in Arts and Humanities. Some learners, females especially thought because they are females, Mathematics is for males alone who are to be prepared for Science, Technology and Mathematics-related courses and males on the other hand thought such disciplines are male-dominated. Such disciplines has their origin traceable to Mathematics and learners as such must be prepared right from the beginning to be well acquainted with Mathematics since the disciplines of STM is not specifically for a particular gender

Computer

Computer as an instrument whose language is Mathematics-based relied heavily on Mathematics for most of its activities. The learning of Mathematics could as such be enhanced through the use of computer. Computer assists learners especially whose level of comprehension is below average to as a matter of time. learn some Mathematical concepts cogently well. The advent of computer technology revolutionalized how students can best learn Mathematics through most of its packages and the possibility of making a subscription to online journals to be receiving recent researches in the field that are capable of making the learner sound. Computer could be used in a number of ways in the process of learning Mathematics such as interactive tutorials through the use of projectors, hypermedia and simulation and education games. Another way that Mathematics could be learnt is through computer assisted instruction (CAI). Computer Assisted Instruction refers to the instruction or remediation presented on a computer. They can be used to enhance teacher instruction and assist learners to learn a lot of Mathematical concepts in the best way possible. These computer programmes are interactive and can illustrate a concept through attractive animation, sound and demonstration. They allow students to progress at their own pace and work individually. Computer Assisted

Instruction (CAI) improves instruction for students with disabilities because students receive immediate feedback and do not continue to practice the wrong skills. The programme (CAI) keeps students track of errors and progress. These are few out of many ways that computer can be used to make students learn Mathematics the best.

Conclusion

The role of Mathematics in the world now cannot be over emphasized because it cuts across various disciplines in Science, Technology and Mathematics (STM). An understanding in Mathematics is known to facilitate achievement in Physics, Chemistry, Biology, Mechanics and Engineering (Oakali, 1996). As such, Mathematics has to be made in such a way that it is well understood by students so that their achievement in their chosen area of endeavor would be guaranteed

Recommendation

It is highly recommended that teachers should be well trained and should be provided in large quantity so as to take care of the ever increase in the need of knowledge acquisition in Mathematics and Mathematics-based courses

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