EDUCATION:

BUILDING A SOUND MIND AND SOUND BODY

A BOOK OF READINGS

IN HONOUR OF

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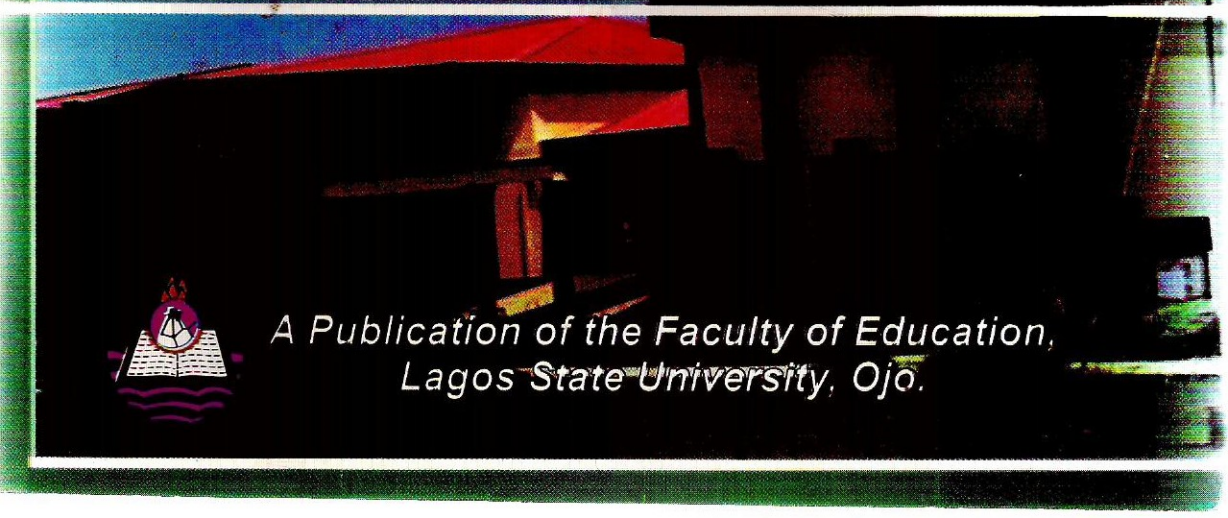

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CHAPTER 9

INNOVATIONS IN STRATEGIES AND RESOURCES FOR EFFECTIVE MATHEMATICS INSTRUCTION IN AN ICT ERA

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Abstract

The teaching and learning of mathematics in schools requires the teacher's ingenuity in selection of appropriate media and methods. The need to improve delivery of mathematics instruction is hinged on persisting report of decline in students' performance in mathematics and mathematics related subject in public examinations. This paper identifies innovative strategies and resource potentials available at the dispatch of mathematics teachers in an ICT era as an avenue for encouraging effective teaching and learning of mathematics in schools.

Introduction

Education is especially valued in developing countries. Not only is individual success dependent upon sound education, but national progress, too, turns ultimately on the aspirations and awareness of the populace. Unfortunately, although the needs of such countries are severe, so too are their problems. Developing countries have serious financial constraints often coupled with high birth rates, which tend to result in overcrowded, under-funded schools and an insufficient number of trained teachers. Moreover, such states are usually burdened by a highly centralized and conservative bureaucracy. This can give rise to an education system in which teachers are constrained to follow a detailed curriculum, the contents of which students are expected to learn, almost parrot-fashion, in order to succeed in highly competitive examinations. Despite widespread recognition of the system's failure to prepare students for a rapidly changing world which demands flexibility and independence of mind, innovation seems practically impossible.

Mathematics has been variously defined as a language which provides an indispensable means of investigating the nature of the things particularly those which are dealt with in the fields of science, technology, engineering and industry (Umaru, 1995). There can be no real technological development without a corresponding development in mathematics both as conceived and as practiced (Ezeilo, 1981).

This importance of mathematics to national development is recognized in the national policy of education (FGN, 2004; revised) which makes mathematics a compulsory and one of the leading core subjects in the primary and the secondary schools curriculum.

Despite the prominence given to mathematics as a school subject, and the increasing efforts of different government in Nigeria to provide material for its study, there have been several reports of decline in students' performance in the subject in public examinations (STAN, 1992). This calls for attention of all stakeholders to evolve ways of improving the teaching and learning of the subject.

Several factors have been identified to influence effective teaching and learning of mathematics and other school subjects. These include teachers' related and Student related factors among others (Buhari, 1994; Ifamuyiwa, 1999).

Among these factors, the competence of the teacher affects the outcomes of classroom instruction. This fact is reiterated by Otuka, Oshadumo and Olorunkooba (1987). According to them;

No matter how well our thoughts about science have been developed and documented, no matter how realistic our objectives are, the success of our science programmes depends to a great extent on the classroom teacher. It is he in the final analysis who translates our thoughts into actions.

Why Innovations?

There is a critical need to restructure the methodology of teaching mathematics and science. The traditional way of teaching is through reading from the textbook and doing problems through rote memory of formula and facts. Hands-on experiences, when used, are only to verify "the facts" stated in the textbook. The situation is exacerbated for special education children. A shift to more dynamic and hands-on methods is required. An active, multi-sensory approach to science and mathematics can be effective for children with disabilities, as it is with any other child. The teacher who relies on reading and writing as the sole means of instruction presents all of his or her students with a disadvantage. Children with disabilities may need to carry out their explorations differently.

Educational technology can be a powerful force for change in education. However, technology can not be considered a panacea for educational reform (Kimmel and Deek, 1995). Technology, when properly used as an integral part of the curriculum and the instructional approach, can be a very effective tool for improving and enhancing instruction and learning experiences in the content areas involving all students in complex, authentic tasks. The use of technology in the classroom can give all students a learning environment that allows discovery and creativity through the use of computer visualizations, such as modeling and simulations, and has the potential to dramatically change the way we view science and mathematics. Opportunities can range from achieving greater independence and maximizing productivity to connecting with the virtual communities across the world and sharing information and ideas (O'Shea, Kimmel, and Novemsky, 1990). Special needs students can be provided with access to technologies that empower and enable them to be successful in an inclusive learning and working environment (Holzberg, 1995; Wiburg, 1995).

Technology can support the kind of student learning advocated by current educational reform. However, enabling students to benefit from such tools goes beyond the availability of technology in school systems.

Teachers must be ready and equipped to prepare and deliver instruction using new approaches which include technology, and hands-on and collaborative teaching.

Innovations in Strategies for Effective Mathematics Instruction

Even though teacher may be skeptical about innovation, there have been significant changes in recent years in the ways in which mathematics has been taught, learnt and assessed in schools. There are changes from the ways of the previous generation of lecturers and students and they have come about, perhaps, as the result of a number of different influences.

There have been six or seven major influences on the British higher education scene over the last 15 to 20 years which have acted in one way or another to bring about change.

In the Cockcroft Report, (Cockcroft, 1982). Paragraph 243 did suggest that mathematics teaching *at all levels* should include opportunities for exposition by the teacher; discussion between teachers and pupils and between pupils themselves; appropriate practical work; consideration and practice of fundamental skills and routines; problem solving, including the application of mathematics to every day situation; investigational work.

The emphasis on *at all levels* is suggests that some innovative teachers in higher education incorporated these ideas into their teaching. This would be particularly true of the teaching of mathematical modeling. Some academics with industrial experience realized that there was little connection between the teaching of applied mathematics in universities and the doing of applied mathematics in industry and so promoted innovation in this area. Ideas were disseminated through the series of International Conferences on the *Teaching of Mathematical Modeling and Applications* and the journal of Teaching Mathematics and its Applications, and the practice was encouraged, at least in the polytechnics, by the Council for National Academic Awards.

Shortly after this came the **Enterprise in Higher Education Initiative,** (TEED, 1989) the principal aim of which was, unsurprisingly, to encourage students to be "more enterprising". Many institutions took this to mean that students' transferable and core skills should be developed. Thus group work, written and oral communication and problem solving were all introduced into the teaching of mathematics and many other subjects as well. Students were to be better prepared to contribute to and take responsibility in their professional and working lives. They were to be independent learners and they were to be able to assess their own performance and that of their peers. These principles have given rise to many innovations involving self and peer assessment, independent learning and peer tutoring, all within the context of mathematics teaching.

Working away in the background, and underpinning many of these innovations were several research studies on student learning. Various authors (Marton and Saljo, 1976a,b; Marton *et al.,* 1984) suggest that students approach their learning in different ways. They may take what is called a "surface" approach if their intention is merely to memorize facts in order to answer examination questions. On the other hand if they seek to understand and to make connections between new knowledge and their existing knowledge, they are said to be taking a "deep" approach to learning.

It has also been observed (Ramsden and Entwistle, 1985) that a student's approach to learning is not fixed but may vary according to circumstances and can be affected by teaching and assessment methods and by course design. Some authors (Gibbs, 1992, Denicolo *et al.,* 1992) have also suggested that "active learning" encourages students to take a deep approach to their learning. Thus Gibbs would encourage us to develop teaching methods which promote active learning and several innovations have sought to do this.

Active Mathematics Teaching

Active Mathematics Teaching (AMT) is a form of instruction developed by Thomas Good and Douglas Grouws (Chambers, 1987; Good & Grouws, 1977; Good, Grouws, and Ebmeier, 1983). It has proved effective in teaching large bodies of highly structured materials such as basic mathematics skills. AMT is a structured teaching sequence typically organized into a 45-minute lesson:

Review (5-10 minutes);

Develop New Content with Controlled Practice (20-25 minutes); and

Seatwork and Homework (10-15 minutes).

This method of organizing instruction can also be used effectively with other content areas such as science or social studies. AMT was originally developed for whole class instruction, but it can also be used with small cooperative groups (Slavin, 1989).

Three characteristics of AMT make it especially suitable for teaching math to LEP students. First, since this method is highly organized and structured, students receive continuous reinforcement with contextual clues about both the content of the material and the structure of the lesson. Second, during the content development portion of the lesson, the teacher can modify the activities for individual students. Third, during the seatwork phase, the teacher can work individually with students who need additional instruction.

Cognitively Guided Instruction

Cognitively Guided Instruction (CGI) can be an effective approach for teaching mathematics to students. It can be integrated into the AMT approach or can be used as a stand-alone method. Developed by Thomas Carpenter and Elizabeth Fennema, it focuses on students' thought processes while solving mathematics problems (Carpenter, Fennema, Peterson, & Carey, 1988; Carpenter, Fennema, Peterson, Chiang, & Loef, in press). CGI is based on four related teacher competencies:

- Teachers should know how specific mathematical content (e.g., addition and subtraction) is organized in children's minds;
- Teachers should be able to make solving mathematical problems the content focus;
- Teachers should be able to assess in what way their students are thinking about the content in question; and
- Teachers should be able to make instructional decisions (e.g., sequencing of topics) based on their own knowledge of their students' thinking.

Teachers can receive training to attain these competencies through a variety of federal, state, and local programs, such as pre-service training, in-service training, and additional training and technical assistance from state and local sources.

Cognitively Guided Instruction can be particularly effective for teaching math to students for several reasons. First, students receive basic skills instruction in a problem-solving context that is meaningful and fosters higher order thinking skills. Second, as students become proficient at problem solving, they develop confidence in their abilities to make sense out of new problems. Third, problem solving motivates students to stay on task since it is cognitively challenging.

Suggestions for Implementing Cognitively Guided Instruction

When using Cognitively Guided Instruction, teachers and students work through the exercises in the lesson, and the teacher can ask the students how they arrived at their answers, that is, what strategies they used to answer the questions.

For example, in the graph on page xy, "What part of the world did most of the students come from?" Some students may say they looked at the chart to see which line on the graph the least amount of students had represented. Others may say they added each line and then answered the question. Others may say they were not sure how to answer the question.

With CGI, the important factor is to learn how the students ascertained their responses. Teachers should explain to them that there are several ways to solve a problem. This enables the students who answered incorrectly to learn how to arrive at the correct answer. Students can learn how to approach problems in different ways through the examples of their peers

and choose the problem-solving methods with which they feel most comfortable. This increases self-confidence and the motivation to learn.

CGI can also help teachers focus on how their students solve problems. Once teachers focus on how their students solve problems, this information can be used to individualize the way the teacher approaches the content for different students. For example, the teacher may find out that some students prefer to learn mathematical rules and then apply them, while other students prefer to solve mathematical problems by trial-and-error. Implementing CGI gives the teacher additional insight into individual learning styles and allows the teacher to modify the lessons accordingly.

ICT Based Resources for Mathematics Instruction

Computer technology has changed out of all recognition since the last generation. 15 years ago students used mainframe computers to carry out numerical computations on a grander scale than ever before. They learnt how to programme numerical algorithms. Today virtually all the algorithms they are likely to need are available in software libraries and what students have to learn now is which algorithm to choose and how to apply it to their problem. Also today we have software packages which do hard algebraic sums as well as hard arithmetic ones. With computer, we can investigate mathematical problems deeper and wider.

Some innovators are experimenting with the use of such systems in their mathematics classrooms, and it should be noted that some of this technology is available on personal, portable, hand-held computers.

According to Sung (2007) Incorporating emerging technologies into mathematics instruction can help such students to learn mathematics their way. For example, mathematical concepts, such as those in calculus, can be visualized dynamically and animatedly using hand-held video iPods, versus illustrated by static graphics in a textbook. Augmented with audio through iPods' notes function, it can guide student inquiry.

It not only keeps students interest, but also helps students grasp mathematics concepts and problem solving processes. Students can be taught to show their mathematical thinking and explain the meaning behind their solutions. From their own discovery, students increase their understanding of mathematics

Furthermore, there has been considerable development in the creation of computerized teaching packages. These are slowly coming on the market and innovators are experimenting with their use in their classrooms.

A visit by mathematics teachers to the internet through any of the search engines will expose him/her to avalanche of innovative strategies and resources available for ensuring effective teaching and learning of mathematics in schools. Some of these resources may require paying sum amount to acquire them, some only require the teacher registration with the group to have access to their software, while there are several free resources for teachers to download and modified for use in their classes.

Teaching Math -ÊResource

Mathematical understanding is a critical process to all teachings. A student that fully understands the process and applications of math calculations will be rewarded with academic success. This resource provides you with the tools required to ensure that concepts are not merely a memorization of the steps or facts - but a deep understanding of 'why' the process works. The ideas and strategies discussed in this book were based on research. The focus of the book is on the role of the teacher and the problem solving, child-centered classroom.

Games for Teaching Mathematics Facts

Practice! Practice! Practice! That's how most students learn their addition facts or times tables. Rote drill is a popular and proven tool for learning math facts. But it's OK to lighten up and add some fun to math-facts learning.

Just as understanding letter sounds is fundamental to the ability to read, so is knowing math facts the foundation to future math learning. That's why teachers in the primary and elementary grades spend so much time practicing and memorizing and drilling and timing students in basic addition, subtraction, multiplication, and division facts. Accuracy and speed are the goals. Work sheets and timed tests and games are often the tools.

Games -- relay races, card games, and computer games -- actively engage students as they reduce stress and make learning fun

There are several instructional games available online for teachers to adopt for mathematics teaching and learning. The following games for example are available on http://www.nea.org free of charge.

1. Math Facts Race
2. Math Fact War
3. Saved By the Bell
4. Multiplication BINGO
5. Online Math Facts Games
6. Math Magician Games
7. MathMastery's CyberChallenge
8. ArithmATTACK
9. Math Baseball
10. A+ Math's MATHO
11. Saxon Publishers' Basic Math Sheets
12. Pick a Number
13. AAA Math
14. A+ Math's Hidden Picture Games
15. Quia Concentration
16. Quia Matching
17. A+ Math's Concentration Game
18. Multiflyer
19. Math Mayhem
20. Coloring Book Math
21. MathCats Explore Multiplication
22. Multiplication Quick Flash

Recommendations

In summary, the mathematics teacher needs to be creative, innovative and dynamic in his choice of instructional strategies and resources for effective classroom instruction. He needs to explore every resource at his disposal which includes looking inwards to local resources that can be adapted or adopted for effective teaching and learning as well as collaborating with colleagues across the globe. In doing all these, peculiarity of the learner and learning environment should be adequately considered. If all these are taken into consideration, poor performance in mathematics and perhaps other subject will become history, and Nigeria will be able to achieve its goals of technological advancement.

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