The Use of ICT in Education for Improving Engineering Education and Training

Gambari, A. I. and Oyedum, N. A.
Department of Science Education, Federal University of Technology, Minna, Nigeria
E-mail: gambarii@yahoo.com

Abstract
The benefits of ICT in science, technology and mathematics (STM) education are several and desirable. This paper outlines the role of CAL software, its importance, scope, merits and systematic procedures for its development. It recommends and suggests collaborative strategies for integrating ICT into science, technology, and mathematics education for effective teaching and learning at all levels of the educational system in the country.

Keywords: *Computer-Aided Learning (CAL); CAL software; Individualized instruction; STM education; ICT, Engineering education, Engineering training.*

Introduction

Science and technology have developed through the centuries. The importance of science for technological development cannot be over-emphasized. Bajah (1995) concluded that we are surrounded by science and its application. Our lives and attitudes are influenced by science and technology. Science, technology and mathematics have altered economic, social and environmental conditions of mankind in the areas of food production, medicine, transportation and communication, environmental improvement and protection as well as energy production and renewal (Mars, 2003). The importance of STM as vital tools for solving myriads of problems that confront humanity, as well as accelerating the pace of industrialization in the society, has long been recognised by the Federal Government of Nigeria (FRN, 1988). Hence the teaching and learning of STM is being seriously addressed at all levels of her educational system.

There are lots of problems facing the effective teaching of pure science, applied science and engineering-related disciplines at all levels of our educational institutions. One of such is the problem of communication channels through which pieces of information, ideas, concepts could be disseminated to learners. Effective communication through appropriate media is paramount to effective teaching (Babajide and Bolaji, 2003). Bajah (1995) found that science has not been taught in Nigerian schools the way that pupils would benefit most, as science instruction has mostly been teacher-centred.

For the past two decades, STM education has been facing a lot of difficulties which include poor performance of students in science (Adeyegbe, 1992); inability of science teachers to put across science concepts to students; inability of students to understand the science concepts; apprehension by students that science is difficult to learn; lack of skills and competence for teaching science and shortage of qualified science teachers (Akale, 1986; Okebukola and Jegede, 1986). Many of the students see science as too abstract to comprehend, thereby resorting to memorization or rote method of learning. Many researchers have traced the poor performance in STM to lack of resourceful and creative science teachers. Effective science teaching and learning should involve students' active participation in the

teaching and learning process. Lack of active participation of students is one of the factors responsible for students' poor performances in science subjects (Inyang, 1988; Bichi, 1988). This has also been indicated in WAEC results of secondary schools where students' performances are generally poor in physics, chemistry, biology and other science-related subjects (WAEC, 2000). This pattern of poor performance in STM education by students is also observed in tertiary institutions (Olarinoye, 1987).

The Science Education Project for Africa (SEPA) of 1971 emphasised the need to change from teacher-centred to pupil-centred learning and the effective use of instructional materials. Ogunleye (2000) found out that in the era of technological advancement, technology has had minimum impact on education. This is because 80% of teachers in Nigeria are mostly using the chalkboard and textbook method (traditional method) in teaching. Actually, most schools do not have modern equipment and materials. The few schools that have these equipment are unable to use them effectively as a result of erratic electric power supply and at times the inability of some teachers to operate some of these equipment. However, constant use of the traditional method of teaching is a major factor contributing to poor academic achievement of STM education.

Computer has been used in developed countries to tackle most of these problems. It can also be used in the Nigerian educational system. Computer can be used to teach all school subjects including science. In recent years, the use of computer in the process of teaching and learning has become widespread in educational institutions with the development of microcomputer (Ezeliora, 1997). Computer is basically used in the process of teaching and learning as a medium of instruction and computer science is a subject being taught and learnt today at all levels of the educational system.

ICT in Education

Information Communication Technology (ICT) consists of hardware, software, networks, and media for collection, storage, retrieval, processing, transmission and presentation of information (voice, data, texts and images). On the other hand Information Technology (IT) which is a component of ICT refers to the creation, storage and processing of data including hardware systems, software and software applications (World Bank, 2002). The need for the development of ICT in education is a global resolution and has been a subject of great significance to all mankind (Uwaje, 2000). Most of the developed countries have exploited the potentials of ICT to transform their educational landscape at the tertiary, secondary and even primary school levels particularly the instructional process. Generally, IT holds out the opportunity to revolutionalize pedagogical methods, expand access to quality education, improve the management of education system (World Bank, 2002). Unfortunately, in Nigeria, the traditional chalk-and-talk modes of STM education have remained largely unchanged (Adamu, 1992). Already Nigeria is almost two decades behind in embracing the use of computer in primary and secondary classrooms (Ezekute, 2000). There is need to brace up to the new challenges and systems of education through the development and use of ICT in schools. When properly integrated into a broader educational program, the most important roles of ICT in education are as pedagogical tools (World Bank, op.cit). How ready are the STM teachers to use these tools? This work looks into the knowledge and skills required to develop Computer-Aided Learning package.

Computer-Aided Learning (CAL) software could be used to transform classroom instruction into a series of rich memorable experiences and thus reduce boredom and forgetfulness. Computer-Aided Learning (CAL) is the general term used to describe virtually any learning activity that is promoted by a computer or in which a computer is involved. Sometimes the synonymous term Computer-Aided Instruction (CAI) is used to describe these activities (Hudson, 1998).

Scope of CAL

The scope of CAL includes a variety of instructional functions such as management of learning, testing, tutoring, exercising, calculating, laboratory work, production of teaching materials, dissemination of materials, archival of materials, and medium of expression. CAL modes include problem-solving, drill and practice, inquiry mode, simulation, games, tutorial mode, and dialogue mode.

Depending upon the relative degree of involvement by the learner, two basic types of CAL are identified. Passive CAL (as might be used in a computer assisted lecture) involves the use of computers as teaching/learning instructional media - but there is no direct involvement by the student. In contrast, interactive CAL promotes active learning in which there are high degrees of participation and involvement by the student. That is, the student's behaviour (and responses to instructional material) can be used to help determine the most appropriate pathway through the body of knowledge for each individual student. A very important aspect of interactive learning is that the student can get instant feedback about the correctness (or otherwise) of what he/she is doing. If the wrong approach is being used, help can be given at the time it is needed and when the student will benefit from it, not in a post-learning phase where its impact may be lost. Each of the two categories of CAL may be used at different levels and times, for instance at the initial stage of introduction of new topics or subjects to students, passive CAL could be useful. On the other hand, interactive CAL would be more useful in situations involving learning by discovery (Philip, 1987).

Functions of CAL

One of the important CAL functions is the record keeping abilities and analytical powers which enable computer to monitor a student's progress through instructional material, and generate reports that can be used either for self or peer group assessment.

In the teaching process both the teacher and the computer assist learners. The computer is used to programme school lessons including science, technology, and mathematics lessons. The programmer who is a specialist in the field does the programming. The programmed lessons are stored in the hard disk of the computer or compact disc or as software on the diskette. In whatever place it is stored, the learner can go through the lesson several times. With the programmed topics or lesson(s) stored in any form, the learner can go through the topics at his/her own pace. Thus, difficult subjects or topics would be mastered well. The CAL also takes care of individual differences in learning ability. This computer learning process has enhanced students' understanding and achievements in school subjects.

Udousoro and Abimbade (1997) and Adeniyi (1997) pointed out that students taught mathematics and physics with computer achieved higher cognitively than those taught

without computer. In learning with the computer, the students do not need an advanced knowledge of the computer. The computer directs the student on what to do at every step. Internet, which is a computer network, aids students in gathering vital information on any school subject/topic and in any area of interest.

The computer is a good learning instrument and a companion for the learner while it serves as an able companion and helper for teachers. Using the computer-programmed instruction, the teacher can teach as many students as possible without over-working himself /herself.

Advantages of CAL Package

According to Philip (1978) and Abimbade (1997), Computer-Aided Learning (CAL) has a lot of advantages in areas of direct instruction that include the following: It

(i) helps students to learn at their own pace.
(ii) produces significant time saving over conventional classroom instructions.
(iii) allows students' control over the rate and sequence of their learning.
(iv) gives appropriate feedback.
(v) promotes individualized instruction through personalized responses to learner's action to yield a high rate of reinforcement.
(vi) provides a more positive affective climate, especially for slower learners.
(vii) provides appropriate record keeping and thereby monitors students' progress.
(viii) puts more information in the hands of teachers.
(ix) provides the novelty of working with a computer which raises students' motivation.
(x) provides reliable instruction for learner regardless of the teacher/learner at the time of the day and the location.
(xi) directs instruction to learners; and
(xii) provides instruction at comparable expenses to other media.

Courseware

The term courseware is often used in a generic sense to describe materials that are specifically designed and produced for use within some form of teaching machine (Philip, 1987). Courseware can best be regarded as a combination of: (i) a set of instructional strategies, (ii) their assisted domain – dependent subject matter and (iii) the storage media to which each of (i) and (ii) are committed.

The Development of Courseware (CAL Package)

The development of courseware for this research material follows the systematic and recursive approach of instructional development model put forth by Mervill and Goodman (1972); Philips et al. (1987); and also Dick and Carey (1996). Philips et al. (1987) identified a list of the basic factors that need to be considered during courseware development as follows:

(i) Is there a need?
(ii) Who is to be taught?
(iii) What is to be taught? (Knowledge, facts, skills-TASK ANALYSIS)
(iv) What level of instruction is needed? (Introductory, awareness, advanced, etc)
(v) How is the material to be taught? (Need to design: lesson plan, techniques of presentation, tests of understanding)
(vi) What resources are to be used?

(vii) Assessment of the effectiveness. (Use standard evaluation techniques such as Prototyping and field tests)

(viii) Revision. (Modify instructional materials in the light of experience with them)

The first step identified by Dick and Carey (1996) is to assess and identify instructional goals. From there, the teacher performs an instructional analysis by examining the skills necessary to achieve the task. While conducting the instructional analysis, the learners are analysed and the environment where they would be performing the learning task duly considered. Performance objectives are then written based on the instructional, learner, and context analyses. The next steps according to Dick and Carey's (1996) system of design are to develop an instructional strategy and select instructional materials. The last two elements of this design process involve conducting formative and summative evaluation. Feedback based on formative evaluation is used to revise the instruction; whereas, summative evaluation occurs once a program is completed. The aim of this approach is to give feedback immediately. The development process is revised and cycled back through the design model to return to previous functions for revision or modification.

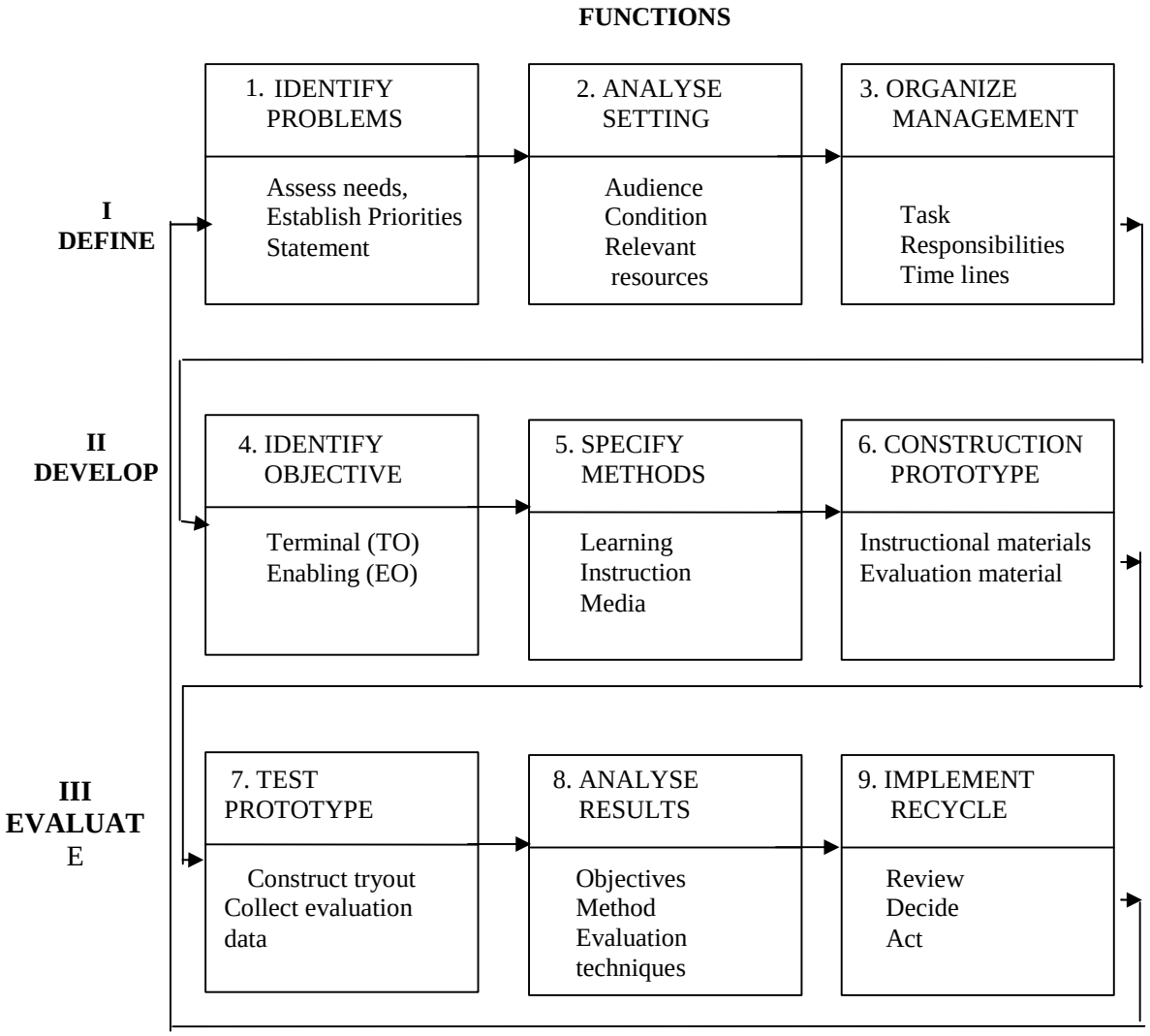

Fig. 1: Instructional Development Model adopted from Mervill & Goodman

Fig.1 visualizes the systematic approach to effective and efficient learning experiences. The flow chart reveals cyclical nature of the model and feedback loop through which improvements are made to the learning design and also to the objective and the evaluation process. For effective CAL to be developed, a good programming language must be chosen.

The Program Language Chosen

The programming language chosen to develop CAL software is the Visual FoxPro. The choice of Visual FoxPro arose because of the following features required of the application software:

(i) It is easy to write an interactive user interface program and also simple to understand.
(ii) It is user friendly, reduces data redundancy, and maintain data integrity.
(iii) It provides easy and greater access to information.
(iv) Individual database file can be designed to meet specification requirements of a particular functional unit of an organization.
(v) The Visual FoxPro allows the source program to be compiled to an executable file thereby allowing the program to be run independent of the application software.
(vi) It has high quality graphical users' interface
(vii) It is easy to maintain and debug; it has debugging tools
(viii) Provision of exit key at any level of the program is of great advantage.

Once the program has been written, the next stage is installation of the software.

The Installation of CAL Software

The installation of CAL software is the process of transferring/installing the developed CAL software programs from the floppy disk/ compact disc to a permanent storage device called hard disk. The following procedures were used for the installation of CAL software for students use:

Table 1: Installation of CAL software from compact disc to hard disc

STEPS	ACTION	RESULTS
1. Go to start button	Click	Start pop-up menu displayed
2. Run Submenu	Click	Run dialog box displayed
3. Insert diskette into A:\	-	-
4. Type the source drive A:\	Browse	Content of A:\ displayed
5. Select set up	Double click	Installation begins
6. Follow the instructions	-	Installation in progress
7. Destination	-	Software install to C:/ successfully.

At the end of the installation, the floppy diskette/compact disc becomes a back up and should be well safeguarded against any damages for future use.

Recommendations

The following suggestions are made towards integrating ICT into STM education for effective teaching and learning:

1. The use of computer for teaching and learning in our schools should be encouraged. Also, in-service training, seminars, workshops and conferences on computer training should be organised for teachers at all levels of education.

2. Government should strive to integrate ICT as part of teaching and learning processes rather than only aim at IT literacy.
3. Science teachers should be encouraged to learn how to prepare Computer-Aided Learning software.
4. Emphasis should be placed on making learning to be a learner-centred affair and more effective, efficient and hence meaningful.
5. Government and other stakeholders should provide funds for the purchase of ICT materials and support the use of ICT for teaching and learning.

Conclusion

This paper has made an attempt to look into Information Communication Technology as right step further towards improving the teaching and learning of STM education. The potentials of CAL software package to change teaching and learning from a teacher-centred to learner-centred activity was discussed. If Nigerian teachers fail to acquire the knowledge of computer to improve teaching and learning, the quality of students they produced will not fit into the current technological society. Therefore, efforts should be made by school administrators, government and stakeholders to make our teachers acquire sufficient computer programming ability to develop programmes to meet the students, curriculum, and educational needs.

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