The Potentials of Information Technology in Education

Wakshum Mekonnen*

Introduction

The two major approaches to the classroom teaching are commonly known as: teacher-centered instruction and student-centered instruction. Teacher-centered instruction is the traditional method that does not encourage students' participation in the teaching-learning process. Contrary to this, the student-centered instruction method is based on the intensive participation of students in the process of teaching-learning. The student-centered instruction is primarily supported by the application of information technology (IT), which is supposed to be one of the main components of the student-centered instruction. The current trend is a move from teacher-centered to the student-centered instruction. Why is the move required? How does information technology affect the learning environment? What are the problems that hinder the progress of IT in education? What will the future education system look like? These and other issues dealing with IT in education are to be reviewed in this paper. In particular, this paper will treat technology as a tool to help students accomplish a complex task rather than a subject of study.

Definition of IT

Information Technology (IT) can be regarded as any form of communication between individuals. Smoke signals and semaphore signals for instance are ITs as they could easily establish communication between two points or persons. A very comprehensive definition of modern IT is given below (Source: Internet):

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> ... technology that has emerged from the integration of the previously separate technologies of: computers including microcomputers, work processors and large main frame computers; communication technology, including the telephone, satellite, communications, video and computer communications, facsimile transmission (fax) and the field of fiber optics; microelectronics; data storage technologies; network technologies; technologies relating to robotics, artificial intelligence, hypertext, remote sensing, voice recognition, artificial vision and scanning.

These components are useful in creating, processing and transferring of information. The hardware and software technologies are the main builders of IT. In the education system that employ information technology - computers, online systems, video cameras, software application such as multimedia and simulation tools are common devices that supports student activities and learning process. Alternatively, the term education technology is used instead of information technology in education system. Zia and Mulder (1997) define educational technology as the systematic application of human and technological resources in teaching and learning.

Likewise, the National Science Foundation Workshop (1996) described IT from the point of view of education and stated that

> information technology broadly includes the computing infrastructure, the communication infrastructure, and by extension of these, the institutional infrastructure (e.g. multi-campus consortia) and instructional infrastructure (a range of courses from small classes taught by one faculty member to large, team taught or distance learning courses).

In this context, IT encompasses all means that are useful for the delivery of knowledge in the educational system.

Overview of Early IT Design

The development of assimilating new technology in the education process might have started two decades ago. A number of developments in 'tutoring system, learning system, networks in education were designed at different times and were tested by incorporating them in the curriculum of schools and other occupational institutions. Collins (1996) examine some of these designs of IT in education. For instance, he studied SCHOLAR and STEAMER systems, computer software designed in the 1970s. SCHOLAR was computer aided instruction system that had a capacity to acquire knowledge to give readily answers to questions and posing questions to students and tc evaluate their answers. It had knowledge of South American Geography stored in a semantic network. The system also incorporated simulator that enabled users to evaluate student hypothesis.

STEAMER was designed to help naval personnel learn how to shut down shipboard steam plants under different conditions. This system was developed based on three important notiohs. One was the usual simulation that enabled the learner to see what was happening inside pipes when the valves were turned on and off. The second notion was that the learner would be able to interact with the system by clicking on visual icons as opposed to the case in natural language that merely transferred the theoretical aspect of a given knowledge. The third is the notion of a conceptual model of the system as opposed to a physical model, which may be inconvenient for learning process. In general, these systems were structured systematically for ease of teaching-learning process. It could be shown that successive developments of IT in education were based on such early designs.

IT in Teaching and Learning Process

For a long time schools and universities have been defined as buildings with classrooms, teachers, students and blackboards. In

such a system, curriculum is designed in such a way that students have to absorb what the teachers tell them or instruct them to know. With the development of information technology, the teaching and learning process had been changed from the one that restricts the activities of students to the environment that allows students to have intensive participation and interactions. Simonson and Thompson (1997) view such a system as a *constructive learning* environment that allows learners to engage in real world activities. The former education system on the other hand, is refered to as a *traditional or instructional method* of teaching.

With the development of IT, the society soon realized that the teacher-centered delivery of instruction was not adequate to prepare students for the future. There was a critical need for restructuring the teaching and learning processes. Students should be independent thinkers to explore complex problems in order to apply what they learned to the real-life situations. In the age of information technology, universities and schools are connected together by electronic network and thus the role of teachers has changed from teaching to somewhat guidance activity. The design of curriculum in the new environment is carefully constructed to produce a man of tomorrow. Simonson and Thompson identify five important curriculum areas for children in the information age. These are problem solving and critical thinking, information handling skills (accessing, manipulating, synthesizing, and evaluating), global awareness, technological skills and ability to collaborate and cooperate with others.

Sanholtz, Ringstaff and Dwyer (1997) identified the benefits students may gain from the application of IT. They expressed this as follows:

> The benefits of technology integration are best realized when learning is not just the process of transforming facts from one person to another, but when teachers' goal is to empower students as thinkers and problem solvers. Technology provides

> an excellent platform - a conceptual environment when children can collect information in multiple formats and then organize, visualize, link and discover relationships among facts and events. Students can use the same technologies to communicate their ideas to others, to argue and critique their perspective, to persuade and teach others, and to add greater levels of understanding to their growing knowledge.

From the same perspective, Simonson and Thompson further described the distinctions between the two school environments. The summary of the comparison of the traditional classrooms and the constructive classrooms is given in the following table.

School Environments

Traditional classrooms	Constructive classrooms
- Teacher centered	- Learner centered
- Curriculum is presented part to whole, with emphasis on basic skills	- Curriculum is presented whole to part with emphasis on big concepts
- Strict adherence to fixed curriculum is highly valued	- Pursuit of students questions is highly valued
- Curriculum activities rely heavily on text books and workbooks	- Curriculum activities rely heavily on primary sources of data and manipulative materials
-Students are viewed as a "blank slates" on to which information is etched by the teacher	- Students are viewed as thinkers with emerging theories about the world
-Teachers generally behave in a didactic manner, disseminating information to students	- Teachers generally behave in an interactive manner, mediating the environment for students
-Teachers seek correct answers to validate students learning	- Teachers view the students' points of view to understand students' current conceptions for use in subsequent lessons
- Assessment of student learning is viewed as separate from teaching and occurs almost entirely through testing	- Assessmertt of students learning is interwoven with teaching and occurs through teacher observation of students at work and through student exhibitions and portfolios
- Students primarily work alone	- Students primarily work in groups

The interactive learning environment that chiefly implements ITs provides favorable ways of teaching which human teachers could not perform. In general, in the interactive learning environment, it is the learners who perform most of the activities and the teachers facilitate the process and provide the guidance.

Characteristics of Interactive Learning Environment

Several systems have been developed in different times to facilitate the learning environment. Nevertheless, the goals of some of these systems are usually not compatible with that of learners and thus they become ineffective. Having assessed a number of different designs on student modeling and language processing, Collin (1996) came up with some characteristics of interactive learning environment that could support learning which can not be easily provided by schools. These characteristics are realistic situations, simulation, animation, voice, video, diverse knowledge sources, multiple representations, interaction, scaffolding, and reflection. They are supposed to be the bases for interactive learning environment. Brief descriptions of each are given below (Collins, 1996).

Realistic Situation directs students what they should do. It enables them to design various systems such as airplanes, trouble shooting electrical circuits or gathering television news program. The realistic situation is so adaptive that the easier task comes before the harder one.

Simulation allows students to attempt different courses of actions and provide several options to deal with. It is characteristic in which learners are able to discover new situations. Through simulation, everything looks like what is done in real life. Simulation is an important technique; for example, in .training of pilots and plastic surgeons. Candidates of piloting will simulate hundreds of times and thus gain a great deal of skills before landing at a real airport.

Animation allows learners to view complex and remote phenomenon or process that cannot be realized under normal condition. Processes like blood circulation in a body can be easily revealed by animation technique. Animation highlights the important aspects of process and makes the invisible to be visible. The incorporation of *voice* in an interactive learning system is used to explain the activities going on. Expert advises, hints and precautions are to be presented in voice to enhance the activities of learners. *Video* enables learners to relate the abstraction of situation with the real one.

Diverse Knowledge Sources include information resources available on the electronic network, experts, students from different parts of the world and provision of help facilities whenever students encounter difficulties. The system provides different mechanisms for accessing knowledge.

Multiple Representations present the different characteristics of the same situation simultaneously. Through such representations, students are able to identify the various relationships of different situations or processes.

Interaction characteristics permit learners to see the results of their activities. In the course of learning, expectations and predictions can be confirmed or disconfirmed and enables one to assess the relative effectiveness.

Scaffolding may include tasks like hint or buttons to click when help is required or for other functions. Scaffolding guides learners to perform tasks that are beyond their capability until they manage their learning by themselves. It is generally a support system that helps learners to perform different activities in problematic situations.

Reflection is a facility that encourages learners to evaluate their current and previous performances. It is a way learners detect their mistakes and look for correct ones.

These characteristics of the interaction learning environment that chiefly implements Its provide favorable ways of teaching-learning which human teachers could not perform. Teachers in such a system have little to do in classrooms unlike in that of the traditional method of teaching, as the learners carry out most of the tasks.

Categories of Computer Software Used in Education

There is quite a large number of computer software designed to enhance the learning process. Some of them are: Computer Assisted Instruction (CAI), Computer Based Instruction (CBI) and Computer Based Learning (CBL). Despite the differences in terminology, they are all designating computer applications in education. CAI is the most commonly used term to describe the interactive learning with a computer with a direct instructional role (Lockard, Abrams and Many, 1997). Computer Assisted Instruction provides instruction in one of the several varieties of formats available with or without the involvement of teachers. CAI has three major characteristics, namely interaction, flexibility and capability of meeting students needs.

Some Uses of IT in Teaching-Learning Processes

Results of Researches on CAI

Lockard, Abrams and Many (1997) drew some conclusions from the findings of the various researches. They made a comparative study of the various achievements of students learning with CAI and those in regular instruction stream based on subject-matter achievement, learning retention and speed, attitudes and problem solving.

Subject-Matter Achievement: It was found out that the scores of students using CAI are equal to or greater than the scores obtained by studies in regular instruction. Further examination showed that the greater difference occurred at the elementary grade levels, with

achievements decreasing as the grade level increases. And there were no uniform effects across all subjects, with mathematics benefiting more and reading/languages, arts less. There were also some variations among the findings of the different researches. However, their final conclusions were identical, i.e., the achievements of students with CAI were much better than those in regular instruction.

Learning Retention And Speed: It was indicated that the CAI improved retention of learning. Students observed higher retention capabilities with CAI than those without the technology. In addition, the use of CAI decreased the time students required to learn a given material.

Attitudes: Students who used CAI had more positive attitudes toward the content than those who did in regular classes. As some research indicated students developed positive attitudes towards themselves and towards learning. Simonson and Thompson also suggested that computer based instruction imprinted positive attitudes in students towards both the content of the lesson and the use of computers.

Problem Solving: Furthermore Lockard, Abrams and Many (1997) showed that the potential of CAI to teach general thinking and problem solving skills was better than what the traditional class used to be. In general, it was shown that students with CAI developed higher problem solving skills than those with out CAI.

Some Practical Applications of IT

Schools (General)

Johnson (1996) identified three major uses of technology in schools. The first use of technology (computers) in schools was to enhance professionals' productivity. This category of use included the software that kept students records, figure payrolls, schedule classes, e-mail

services, and word processing. Others included grading system to be used by teachers and curriculum templates. Computers generally enhanced effective administration of schools related to students' affairs.

In Finland, for instance, as Hopkins (1996) indicated, the entrance examination for admission into universities was given to students via Internet. The online exam was automatically graded and recorded. In doing so, time and money, which was to be expended on stationery items was saved. The students did not need to travel to the university to sit for the exam and thus they saved their money which was otherwise going to be used to pay for travel and lodging services.

Secondly technology was used for "automating" instruction using drills and practice software, Integrated Learning Systems (ILSs), video tapped lessons, computer animated picture books (living books), trivia recall games, low level problem solving and simulation software. This category of IT application provided various facilities to disseminate knowledge (as structured in curriculum) most comfortably and effectively to students.

Thirdly technology was used in schools to serve as information processing and productivity tools. At all grade levels, students used application packages and generally the real world productivity software like word processors, databases, spreadsheets, presentation programs, multimedia authoring tools, e-mail, video production equipment, digital reference materials, electronic indexes, and network search engines to complete automatic complex authentic projects in the proper instructional use of technology.

IT in Universities

Hopkins (1996) discussed some of the information technology in the institutes of higher education. He gave an emphasis to the application

of electronic communication in the universities. The access to the wide area network, especially the Internet, would enable students to exchange ideas with their classmates on/off campus or with other students in other universities located anywhere around the globe. The students would also have to explore the chance the mass of information and knowledge resources on the Internet. Using IT could save time and money. Each course may have its own e-mail 'list' which any student could join. Various substantial information such as lecture notes could be disseminated to all students subscribed to the 'list'. In the process, students could interact with one another or with their teachers. They may discuss the lecture or specific subjects or they may be engaged in dialogue with other students, faculty, or researchers on various issues.

Students would feel very comfortable to express their ideas and discuss any issue when they are out of classrooms more than when they are in classrooms. Vught (1997) stressed that modern information technology allowed an active rather than passive learning mode, and simulated team learning and team problem solving rather than individual learning. Students are involved in the active learning process, may take great responsibilities for their education, seek out information on their own and enhance their motivation.

IT in Distance Learning

Distance learning is another major application area of information technology. It can be described as the use of computers and/or video networks to teach courses to students outside the conventional classrooms (Sawyer, Williams and Hutchinson, 1997). Old Dominion University (ODU) in Norfolk, USA, for instance, is one of the leading institutes that offer distance learning (Morrison, at horizon.unc.edu/ts/commentary/1998-03.asp). A lecture is delivered at a studio at ODU to a number of community colleges linked by a satellite. At those colleges, the students who are taking the same course sit in a room where a two-way audio and one way video is installed. Students can

ask questions with a help of an on-line telephone from each of those sites. In this system, students who register for courses at ODU will be awarded their degrees at the end of the four-year period (or at the completion of their courses), yet they may never have set foot on the campus of ODU.

With such facilities, students need not attend the traditional classrooms physically as long as they can be on line from wherever they are. The network provides facilities through which students can interact with their teachers. As Hopkins (1996) pointed out such a facility is of great help for those who are handicapped, who have childcare duties, who work part-time, and who simply fall ill and miss a few days as they can be accommodated through the larger electronic dimension that supplements the physical meetings.

Some of the Students Benefit from IT

Unlike the old forms of media, such as television, and film projects, the computer related techniques are not merely teaching devices but they are also learning devices. Simonson and Thompson (1997) gave the explanation underlying this fact. The computer's capability to interact with students and react with the individual needs has the potential to provide the context for student-centered learning and to assist students in learning to educate themselves. The information technology as a whole thus provides the tools for advancing the new education goal. As Simonson and Thompson (1997) stated, students acquired metacognitive skills and higher order thinking in the new learning-teaching environment.

Metacognitive Skills: According to Simonson and Thompson (1997) one of the most promising benefits computer related technology provide was the possibility of helping students develop metacognitive skill. Metacognition as defined by the same authors is a major field of cognitive and developmental psychology that refers to one's self-

awareness of knowledge and control of cognitive strategies during problem solving. When one responds to an object cognitively, he/she seeks information about the nature and function of the object by asking himself/herself some related questions like, what is it? Who made it? Students in such a process become self-conscious about their learning and problem solving. In doing so, students are selective of the strategies to use and capable of regulating their own strategies. The taxonomy of metacognition has three levels (Lockard, Abrams and Many, 1997): program initiated (the software is in control), guided (the software suggests, but does not require actions), and learner initiated (the learner directs and controls the interactions).

Higher Order Thinking: The other benefits from computers in restructuring learning environment is the development of higher order thinking by students. In such technique of learning, students may go further thinking to know more about a process or they may move further to dig out the reasons for some occurrences or processes. For example, students may be asked to examine hypothesis like, " good electrical conductors are also good heat conductors". In response, he/she would search for a database to find all those elements that fulfill the underlined criteria separately, and then collectively. In the process of searching and thinking, the outlooks of the students are broadened and thus they gain comprehensive knowledge.

The Future

The learning environment of the future can be predicted based on the current state and achievement from the use of IT in education system. Based on the several directions for development, Simonson and Thompson (1997) predicted what the future learning environment would look like.

Discovery Learning Environment: The continuing development of IT would produce student controlled discovery environment in which

students could explore and test hypothesis in particular content areas. The focus would be on developing higher order thinking and problem solving skills.

Interactive Video and Other Combined Technologies: This is the integration of computers with other technologies to produce multimedia student-centered learning environments. This marriage of technology is referred to as hypermedia. The production of videodisk enables the rapid access to thousands of frames or slides and video materials against the video tape which is slow and could only be accessed sequentially. Students would use multimedia to control their own learning.

Artificial Intelligence Application: Intensive research is going on to produce intelligent tutor that will be able to adapt to different student responses in order to guide them in their learning process. Each student will be provided individual computerized tutor in each subject area. These intelligent tutors are said to be equivalent to the human tutors in the teaching process.

Telecommunication Networking: More emphasis is given to develop telecommunications to expand the network capabilities on local and international levels. This will help students to share data and information with other students around the globe over the electronic networks. It enables them to consult their teachers over the network.

Distance Education: the two-way audio and video capabilities of distance education would also develop. This enhances the interactively of students and the accessibility of the network resources for distance education programs.

Sawyer, Williams and Hutchinson (1997) summarized the future of education system as follows.

> Computers can be used to create 'virtual' classrooms not limited by scheduled class time. Some institutions are replacing lecture halls with forms of learning featuring multimedia programs, workstations and television courses at remote sites. The information superhighway could be used to enable students to take video field trips to distance places and to pull information from remote museums and libraries. Of particular interest is distance learning or the " the virtual university...

Problems of Implementing IT in Schools

Ashley (1997) identified three major problems in implementing IT in Schools. These were cost of hardware and software, shortage of trained teachers and equitable distribution. He argued that the limited school budget could not afford the hardware and software requirements in schools in any country. Apart from cost there was also variation in the distribution of computers and other IT gadgets among schools.

Freynfeld and Mitson (1996) identified three basic problems in UK education system in applying the new technology. These were cost, technical question (skilled manpower capable of managing networks and other maintenance) and problem of selecting reliable information on the networks, especially on the Internet. According to McKenzie (1998), though billions of dollars was expended on new IT for education, the result was not as expected. As indicated in many research articles, the problems with schools who tried to integrate IT with their curriculum was not just having a computer but having access to the computers as valuable teaching and learning tools. The schools did not realize much the fact that technology alone would not change education. They tried to develop a system without a person who knew at least about IT as a teacher.

By nature, schools resist changes that affect the existing system. It is shown that schools are networked for the sake of networking without adequate trained staff and preparing the schools to clarify learning goals. McKenzie (1998) stressed the fact that simply cabling or computerizing schools could not eliminate the resistance and inertia of schools. It is not the problem of hardware. The problem is that of cultural and organizational factors. Organizational development is therefore a cure.

The cost of education is continually rising. The majority of population in every country could not afford it. As Vught (1997) pointed out the population growth worldwide is outpacing the capacity to give people access to universities. If a need arises to keep up with higher education with the growth of the world population, according to the same author, one new university should be opened every week. To this effect, Vught (1998) suggested modern information technology in higher education provides an answer to the two problems of cost and access. The uses of multimedia and distance education (tele learning) alleviate much of these problems. For instance, the cost of education per student in the USA is about US $12,500; where as the cost for distance learning for similar courses may not exceed US $350 per student. This is a big difference. Therefore, multimedia distance education offers a very powerful answer to the double crisis of costs and access. New distance learning can help increase access to learning and reduce the cost of education.

The extraordinary pace of technology change, and hence the rapid depreciation through obsolescence of investment in IT equipment are considered another major problem s of adopting the educational technology in schools (Source - Internet). As a result, it is generally very difficult for schools to cope with such technological development. As it is indicated schools are not prompt to accept new changes, where as, the development and obsolescence of IT, especially computers hardware and software is so fast that they could not

match. It is therefore, a predominant problem for schools to get along with the rapidly changing technologies.

The problems in applying IT in schools in the developing countries may be many folds and more crucial than that of the developed countries. The major ones may be the predominant weak economy that is based in most cases on subsistence farming which could not allow them to afford the cost of hardware and software. The other major critical problem is the lack of skilled manpower. As a matter of fact, there have been little intentions and awareness to implement IT in education system in most of the developing countries.

Conclusions

The integration of information technology with the curriculum significantly changes the teaching-learning environment. Students become independent learners by developing their metacognitive skills and higher order thinking. In the new instructional environment that implements ITs, students are not passive; rather they actively participate in the learning process. By using ITs in their learning, students are able to discover new ways to approach problems. And the role of teachers is also changed from providing information to somewhat coaching or guiding students through the vast information resources.

The development and spread of information technology have great impacts on our lives. Being part of the information society, it is mandatory that ITs are influencing the way we do our jobs, shopping, banking and even the way we spend our leisure time. In particular, they are changing the way we are learning. Nevertheless, at present, computer is everywhere excepting in schools (almost none), especially in developing countries. When technology is everywhere, but not in schools, the implied message is that the society is not ready to prepare its children for the future!

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