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Effectiveness of Compuer Assisted Instruction in Teaching Mathematics

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ABSTRACT
The purpose of this paper is to review the changes that computers have on mathematics itself and on mathematics curriculum. The study aims at investigating different applications of computers in education in general, and mathematics education in particular and their applications on mathematics curriculum and on teaching and learning of mathematics. There are three broad categories of the applications of computers in the field of mathematics education: computer assisted instruction (CAI), student (educational) programming and general purpose educational tools such as spreadsheets, databases and computer algebra systems (CAS). This paper presents a historical background and attempts to describe the use and effectiveness of computers in mathematics education from behavior oriented CAI movement towards constructivist based student programming movement.

I. INTRODUCTION

The use of computers in education began in sixties with the realization of its potential to teaching and learning. That was a period of enchantment. According to Suppes et al. (1968) the change that was to come through computers could only be compared to the fact that how books had changed the way of people looking at the world. Computers would change the face of education in a very short period of time by eventually removing the teacher from the classroom scene. Looking in retrospect, can it really be said that his predictions were realized? Or is it just a "techno-Romanism" (Underwood and Underwood, 1990) to believe that the computer is a panacea for all of the problems in education. All though not having been able to solve all of the problems of education by itself, this powerful machine, no doubt, will continue to occupy a very central place in education. A major figure in the history of computers, besides Suppes, in education is Seymour Papert who is famous for his work "Mind storms" (1980) which presents quite revolutionary ideas about the place of the computers in education. He, like Suppes argued that the computer would change the face of education, but unlike Suppes he advocated the use of the computer not as a teaching machine but as a device to develop learners' intellectual skills through writing their own programs to direct the computer and not let the computer direct themselves. It seems that the effect of computer technology on education is greater in mathematics than in any other discipline. This may be because of the close links between the two disciplines. In fact the computer science was a part of mathematics and afterwards gained independence as a sole discipline. The purpose of this study is to review the effects of computers on mathematics itself and its method of teaching. The study aims at investigating the following questions:

1. What are the uses of computers in education, in general and in mathematics education in particular?
2. What are the effects of applications of computers on teaching and learning of mathematics?

THE USE OF COMPUTERS IN MATHEMATICS EDUCATION

Mathematics instruction is among the most explored research area in education. There have been considerably varied computer applications in instruction (Hatfield, 1984). The teachers of mathematics are confused with the extensive amount of suggestions on how to teach mathematics with a computer. Teachers' attitudes towards computers vary mostly as a function of teachers' age or years in service. Complete 'ignorance' attitude towards computers still continues, although its magnitude is weaker compared to past years. This attitude is mostly shared by teachers who had had their training before the start of the computer age who have the most negative attitudes towards its pedagogical use and who insist on using the traditional modes of teaching. Second major attitude is not being able to abandon their traditional habits completely foreseeing its potential for the future of education. Most prevalent and widening attitude is the realization and acceptance of the importance of computers for education.

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CATEGORIES OF THE APPLICATIONS OF COMPTUERS IN THE FIELD OF MATHEMATICS EDUCATION

Generally there are three broad categories of the applications of computers in the field of mathematics education:

• Computer Assisted Instruction (CAI)
• Student (educational) programming
• General purpose educational tools such as spreadsheets, databases and Computer Algebra Systems (CAS).

This survey of literature revealed that, this categorization is also a historical one, although it cannot be said that there were sharp shifts from one movement to another. Another important note is that the CAI movement is not as popular in the Asia as it is in United States.

THE EFFECTS OF COMPUTERS ON GENERAL EDUCATION AND MATHEMATICS EDUCATION

The Russian satellite Sputnik and the paper presented by B.F. Skinner, an influential and famous neo-behaviorist, on programmed instruction had a great influence on education in general and mathematics education in particular. Behaviorism is considered to be the theory underlying CAI. Hence, it is understandable that the CAI programs are mainly behavioral control programs (Hartley, 1981). An example is Skinner's Programmed Instruction (PI)which was designed to change the behavior of the learners. Fundamental approach of Skinner was to identify the desired behaviors, then to prepare situations in which successive approximations of the behavior would be reinforced. All the students study the so called "linear text", the instructional material used by Skinner. When students complete the text, they were assumed to have acquired the behaviors required from them. The basic characteristic of programmed instruction is the small steps approach, meaning the division of the task into small manageable units, and the immediate feedback given to students from each response they give.

The teaching machine is the box designed to expose the programmed instruction text one frame at a time. It is commonly considered to be ancestor of the device called the "computer" to be used for educational purposes. Skinner's programmed instruction formed a basis for the computer assisted instruction movement (Dick, 1986).

Among several other trends Skinner's Programmed Instruction became more widespread than the others. Other major movements in that tradition which followed Programmed Instruction chronologically were Glaser's individually prescribed instruction (IPI) and Keller's personalized system of instruction (PSI). Both approaches contributed to the individualization of instruction movement in similar ways. In Keller's (1968) PSI there were self-paced courses in which students were required to master successive unit tests. Bloom's (1976) is considered to be the last widespread individualized approach to instruction, before computer assisted instruction movement. The method involves the mastery of certain subject area (e.g. trigonometry) before passing to another.

According to Hilgard (1986) these approaches to instruction had important consequences for educational psychology.

• The individualized instruction based on the idea that best learning outcomes can only be obtained with one to one tutoring approach. The claim related to those behaviorist models of instruction was that they could provide learning environments closer to one-to-one tutoring (Bloom, 1976).
• The diagnostic teaching which is based on the immediate feedback obtained from the responses of students to the questions being asked during the instructional process.
• The step-by-step approach they presented in the instruction of a certain learning task. Those programs advance in a way such that one sub-task followed the other, in other words one frame at a time as in teaching machines. Therefore, in each step, what is expected from the user should be specified in terms of observable behaviors.

According to Mager (1962) a *behavioral objective* has four basic components. The first component is the actor or the learner who is supposed to act in the prescribed manner. Second component is the behavior itself. The condition(s) under which that action would occur and the criteria to judge if the behavior is applicable are the third and fourth components respectively.

1.2 Computer Assisted Instruction (CAI)

Computer-assisted instruction (CAI) is an interactive instructional technique whereby a computer is used to present the instructional material and monitor the learning that takes place. It is a self-learning technique, usually offline/online, involving interaction of the student with programmed instructional materials.

CAI uses a combination of text, graphics, sound and video in enhancing the learning process. The computer has many purposes in the classroom, and it can be utilized to help a student in all areas of the curriculum.CAI refers to the use of the computer as a tool to facilitate and improve instruction. CAI programs use tutorials, drill and practice, simulation, and problem solving approaches to present topics,

and they test the student's understanding. It provides:
1. Text or multimedia content
2. Multiple-choice questions
3. Problems
4. Immediate feedback
5. Notes on incorrect responses
6. Summarizes students' performance
7. Exercises for practice
8. Worksheets and tests.

Types Computer Assisted Instruction

Many classifications of CAI available in market, six specific types by Spiro and Jehng (1990, pp. 163-205) seem to be most often utilized for educational purposes.

Drill and Practice instructional programs simply assist the student in remembering and utilizing information that the teacher has already presented, reinforcing previous learning through repetition. It is most important to improving knowledge level.

Tutorials are designed to introduce unfamiliar subject matter. The format of a computer tutorial often emulates a dialogue between the computer and the student, i.e. information is presented, questions are asked of the student and on the basis of the response given, a decision is made to move on to new material or review what has already been presented. These first two CAI types are most successful at improving the *knowledge* and *comprehension* levels of Bloom's taxonomy.

Instructional Games present course content in a competitive and entertaining manner, in an effort to maintain a high level of student interest. Though most frequently used to reinforce factual knowledge at the lower levels of the taxonomy, it is quite possible to create instructional games that demand application skills from all levels.

Simulations require the student to apply acquired knowledge to a novel situation. As a result, the student must analyze a presented scenario, make decisions based on the information given and determine a course of action. The simulated environment must change based on the course of action taken, presenting a significant challenge to the programmer. Successful performance relies on skills up to Bloom's level of analysis.

Problem-solving software requires the student to use high level cognitive abilities in the process of considering the problem at hand, analyzing the problem situation and its various solutions, predicting respective outcomes, determining which specific plan to attempt, and enacting the appropriate action(s) (Shute, 1993, p125). Well designed software that fits this classification may require abilities from all levels of the taxonomy.

However, perhaps the best way to have a student use abilities of synthesis is to have him/her create a novel hypertext system (Jones, 1990, p. 270). In this case, the student would be forced to identify relationships and evaluate all aspects of the chosen set of course materials. Evaluative ability can be tested (and improved) throughout programs representing any of these five types of CAI by prompting the student at significant times during the session and providing appropriate feedback or explanation.

Discovery-environment; in addition to the delineated types of CAI, it is also possible to provide a *discovery environment*(Kendall, 1987, p. 192) within which the student is given a high level of freedom in determining the specific information presented during each session, as well as the order of presentation"(Spiro & Jehng, 1990).

Advantages of CAI

Many researches shown that Computer Assisted Instruction is more effective than traditional methods of instruction. Extra advantages of CAI as identified through the findings of research studies are as below:
• One-to-one interaction
• Great motivator
• Freedom to experiment with different options
• Instantaneous response/immediate feedback to the answers elicited
• Self pacing - allow students to proceed at their own pace
• Helps teacher can devote more time to individual students
• Privacy helps the shy and slow learner to learns
• Individual attention
• learn more and more rapidly
• Multimedia helps to understand difficult concepts through multi sensory approach
• Self directed learning – students can decide when, where, and what to learn

Limitations of CAI

Following are the some limitations of CAI:
• It may feel overwhelmed by the information and resources available
• Learning becomes too mechanical
• Non availability of good CAI packages

Effects of CAI on mathematics teaching

Computer Assisted Instruction is used most frequently and is the most effective for teaching of mathematics courses. Effectiveness of CAI is mo more latent. Widespread and effective use of CAI in

mathematics evident from the availability of various types CAI software for all grade levels in the market. There are games for primary school children and tutorial and drill and practice software for high school students. A large number of research studies have been conducted to ascertain the effectiveness of CAI in the subject area of Mathematics.

A meta analysis of the studies exploring the effectiveness of CAI to teach secondary school mathematics was conducted by Kuchler (1998).This analysis suggest that all the secondary school level computer-assisted instruction(CAI) has an overall small positive effect on mathematics achievement but a medium positive effect on retention of mathematical concepts and skills of secondary school students. The most effective CAI mode appears to be drill and practice with use of combinations of modes being equally effective. Commercially developed CAI software is the most frequently used, but the teacher developed software appears to be most effective. CAI is used most frequently and is most effective for teaching general mathematics courses. CAI mathematics instruction appears to be the most effective when it is used supplement regular instruction.

A qualitative study aimed to ascertain the worth of computer assisted instruction program for intermediate algebra course was conducted by Miller (1999). The main points concerning CAI that emerged from the study were the benefits to students of immediate feedback from the computer, the value of interaction with computer as a means of learning mathematics, and the advantage of individualized instruction. The strengths of the course included clear and consistent instruction, promotion of student involvement and instructive feedback.

Mintz (2000) and Campbell (2000) compared computerized and traditional instructions in the areas of elementary mathematics and elementary readings respectively. Both the studies examined the effect of computerized instruction on the achievement and critical thinking skills of fourth and fifth graders. It was found that there were significant difference in critical thinking skills improvement between students who received CAI and students that didn't.

Above cited research studies and their findings provide evidence in support of CAI to be used in science and mathematics classes. The view that complex learning behaviors comprise of a network of stimuli response associations is the some studies, however, find CAI to be of limited value in science applications. Findings of some studies such as Watkins (1998); White (1998); Hernandez (1999); Watkins don't prove CAI an effective mode instruction. As mentioned by Morse (1991) a major problem in evaluating the result of studies designed to measure the value of CAI is the elusive factor of the quality of the software used in the study. Not only the software be well designed but there also must be a match between the objectives of the software, the understanding of the teacher as to how to apply it, and the needs or interest of the students, is fundamental idea underlying the application of CAI programs. This idea has been the natural continuation of the behavioristic mode of teaching.

Hartley (1981) stated that the stimuli response bonds are established by providing positive reinforcements such as knowledge of results. Then, it was the teacher (or the organizer of the instruction) who was responsible for the selection and arrangement of content to help the desirable responses to be elicited. Then, this process leads to the discovery of feedback, the message which follows the response made by the learner. This, in fact acts as a positive reinforcement for the learner. It is also the information which shows the error and informs the student to correct this error. This is called feedback-corrective cycle. Learning takes place by rewarding the correct associations by questions and answers (Howe and du Boulay, 1981) which is known as the reinforcement learning. Interaction with the teacher and the classmates. This, in fact is very harmful for the process of socialization provided by the school environment. Most of the applications of CAI have been based on the individualized learning, one student working with one computer. The model proposed by Johnson et al (1978) was a group based model. They found that the co-operative CAI was far more effective compared to the individualistic CAI approach in mathematics and concluded that the assumption being "all CAI should be individualistically oriented" is not a valid argument.

Hartley (1977) was the first person who meta-analyzed the findings of CAI on mathematics achievement (in Kulik et al, 1983). He found that CAI had a significant effect (effect size 0.41) on the achievement levels of primary and secondary school mathematics students. Burns and Baseman (1981) also reviewed the findings on the effect of CAI on mathematics achievement. The effect size he found was almost the same (0.45 for tutorial, 0.34 for drill and practice) verifying the results of previous analyses.

In brief, this review of literature revealed that most of the CAI studies and reviews of those studies, as expected, were done in the USA, most of which suggested the effectiveness of CAI. It must be noted, however, that main focus of those studies are generally easily observable measures such as

achievement**,** not more complex phenomena such as cognition.

II. SUMMARY

Computer science had separated from a mathematical logic, and gained independence. That means the improvements in computer science are changing mathematics, hence mathematics education is changing. It caused the revision of the mathematics curricula in many of the leading countries in the world.

This survey of literature indicated that various computer applications in mathematics education contributed greatly to classroom practices. But the limitations of a computer should be kept in mind that it will not solve all deep-rooted problems of mathematics education.

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