COMMENTS ON COMPUTER ASSISTED INSTRUCTION

Charles L. Aird*

INTRODUCTION

The computer is a major force producing rapid change in government, industry, and education. Computers and related information processing in business, industry, government, military, and science throughout the western world have affected the life of every individual; uses ranging from the automatic control of factories to the regulation and monitoring of medical treatments are well known. Uses of computers in education are of some special interest. The first use of computers in education was primarily for research on the graduate level, but as universities developed research centers, educators and computer specialists began searching for ways to apply computer technology to the process of instruction. The development of computer-assisted instruction (CAI) was one result. CAI was in part an outgrowth of programmed instruction, particularly by Crowder and Skinner, during the 1950's. Although programmed materials failed to meet the expectations of many educators, the attempt to individualize instruction using science and technology carried over into computerized instruction.

The advances in computer research and development and software design have been rapid. Program language development has been more important than machine innovations for educational purposes. Many school systems, universities, and manufacturers are promoting languages for education. Over 30 languages and dialects have been produced especially for programming conversational instruction. Atkinson [4] points out:

> ... computer-assisted instruction has grown to a point where several thousand students ranging from elementary school to university level receive a significant portion of their instruction in at least one subject under computer control.

Serious applications of computer-assisted instruction are now in progress, for example, in many universities in the United States. A list of the institutions which have major programs includes Stanford University, University of California at Irvine, University of Texas, Florida State University, Pennsylvania State University, University of Illinois, and Harvard. The University of California at Irvine, which is a relatively new university, has made a serious attempt from its earliest planning stages to integrate computer-based instruction into its total instructional program [1].

Patrick Suppes [13] makes these comments, which and strengthen the educational value of computerized instruction:

> Our new and wonderous technology is there for beneficial use. It is our problem to learn how to use it well. It is our problem to rapidly change centuries old instructional practices to face the educational crisis of the 21st century.

EARLY EXPERIMENTATION

The Stanford-Brentwood Computer-Assisted Instruction Laboratory is an excellent example of work in computer instruction. Funded in 1964 by the U.S. Office of Education, the Institute of Mathematical Studies at Stanford set up this computer-based labratory at a public elementary school. The purpose was to investigate the educational implications of CAI over an extended period of time. The Stanford project is directed by Patrick Suppes and the personnel initially included some 50 psychologists, linguists, mathematicians, curriculum experts, reading specialists, and programmers. After two years of intensive preparation, instruction in mathematics and reading was begun in 1966 with first grade children [14]. The program there has grown and continues to expand into many subject fields.

The early computer-assisted instructional materials were primarily to teach concepts on the lowest level of the learning continuum; that is, the major emphasis was the teaching of skill and knowledge type tasks. Spelling drills, remedial reading and arithmetic programs, simple programming, and games have been the subject of development since the beginnning of computer-assisted instruction [2]. A lesser amount of research has involved the higher

* *College of Industrial Management, University of Petroleum and Minerals, Dhahran, Saudi Arabia.*

level in the cognitive domain of learning. The treatment of proofs in mathematics, algebra and symbolic logic, solid state electronics, and physics are some areas of recent development [1].

Computerized instruction in engineering has recently received a great deal of attention. The University of Missouri-Rolla Wichita State University, and the University of Virginia have introduced CAI supported courses as part of the core curriculum in engineering. The University of Virginia teaches all general engineering courses through self-study computer-based instruction (1). Other institutions are establishing computer networks to share both hardware and software facilities used in engineering education.

ADVANTAGES OF COMPUTER-ASSISTED INSTRUCTION

Computer-assisted instruction is not the panacea for all educational problems. There is no single solution to these complex problems. The main advantages of a CAI system over traditional instruction lies in its potential to permit individualization of instruction. Most teachers, instructors, and professors will agree that there is a need to individualize instruction to meet the needs of every student. Students can learn more at an increased pace when instruction is tailored to their level and rate of instruction. At the secondary and university levels particularly, students do not receive a great deal of individual attention from instructors. CAI lessons designed to accommodate the individual student's rate of progress will provide greater attention. At the same time, instructors released from lecture sessions can provide tutorial sessions, and personalize instruction to an even greater degree.

More specifically, the advantages of a computer-assisted instruction system are its capabilities of:

1. individualizing both the means and ends of instruction.

2. doing research on individualized instruction under controlled conditions.

3. evaluating modes of instruction, teaching procedures and effectiveness of materials.

4. assisting instructors and authors in development of instructional materials.

5. evaluating alternative media used to implement and support instruction.

MODES OF INSTRUCTION

The unique character of CAI depends upon the logic and memory capabilities of the computer demonstrated in the various modes of CAI.

The first of the CAI modes is *problem solving*. This mode is readily achieved through the typical computational capability of the computer. Each student employs a language that permits him a two way communication with the computer and enters the steps and data for solving the problem. The instructor teaches in the traditional manner and does not necessarily become involved with the CAI system.

Another mode is *drill and practice*. The CAI system is programmed to handle drill and practice exercises that are selected by the instructor. These materials are designed to develop skills and give practice to meet minimal course objectives. The instructor is involved to a great extent in this mode. The student communicates with the computer through some terminal device. In order to interact with the machine, he needs to know neither how the CAI system works nor a computer language.

Inquiry is the third mode of CAI application. The CAI system responds to student inquiry with answers stored in data files. The student does not need a language nor does he need to know how the system operates. The instructor must learn the system's operation in order to establish and maintain files and to develop search algorithms that anticipate student questions.

A fourth mode of CAI is *simulation and gaming*. The instructor formulates models of real or idealized situations. The complex relationships among the variables that represent the situation must be learned by the student. The simulation model attempts to represent some real situation, for example, a management or business problem. The instructor defines a situation, the student inputs the variables, and output is determined by the student's input and the model. The student interacts on a terminal in some subset of natural language.

The most complex CAI mode is *tutorial instruction*. In this mode, the instructional staff has responsibility for student instruction on the system. The objectives and logic of instruction are formalized and entered nto the system by a computer-assisted instruction anguage in author mode. The instructor defines the

kind and amount of interaction that will occur between student and machine during the instructional sequence. The specific sequence of instruction for a particular student is then generated by the CAI system based upon information it contains about that student and the factors that influence his instruction. The tutorial mode is socratic in dialogue with the student but can use any of the other modes as needed.

At the lowest level of interaction, systems present material in a fixed linear sequence. Errors in student response are corrected immediately, but there are no decisions made to modify the flow of instruction based on overall response history. Drill and practice instruction is generally presented in such a manner.

Tutorial programs have the capability to adapt to student responses. Decisions are made and instructional branching initiated by the performance of the student on a particular set of materials. Students follow separate paths through the material based on their individual needs. Generally, no two students will encounter the same sequence of lessons. However, adaptive programming is restricted by known response possibilities.

Dialogue systems are under investigation by several educational institutions. Progress has been extremely limited. The goal of the dialogue mode is to provide an unrestricted interaction between student and system. If the student can construct questions or responses in natural language and the system can exercise complete control over the sequencing of presentation, a true socratic dialogue is obtained.

RESEARCH FINDINGS

Educational researchers have reported results and made generalizations concerning CAI.

Some of the conclusions that are available at the present time include the following:

1. Students learn at least as well with CAI as with conventional instruction, and in some instances CAI is more effective in terms of student achievement than traditional lecture/discussion methods.

2. CAI can provide learning and retention equivalent to conventional techniques, often in less time.

3. The computer can manipulate a variety of learning data about the student during the instructional process.

4. Students have favorable attitudes toward CAI.

5. There are no known limits to subject matter or conceptual level which may be presented by CAI.

6. The computer is constantly demonstrating its use as an experimental tool to study how students learn.

Research in CAI has raised many questions concerning pedagogical and technological issues. The effectiveness of CAI has been demonstrated, but how can it best be integrated with conventional forms of instruction? What are the psychological and physiological effects of intensive use of CAI? What individual difference variables interact with materials and modes of instruction? What are requirements for input-output devices and languages? The answers to these questions are at best tentative for many probe areas beyond the implications of CAI. The most critical are questions of a pedagogical nature. Thus, the research on CAI is moving from emphasis on presentation toward emphasis on response. The trend is to employ increasingly complex methods for evaluating and processing student response to presentations.

CAI appears to offer significant potential for individualizing instruction, but exploration and development have barely begun.

Suppes (16) predicts that:

> ... it is fair to forecast that in the next decade the impact of computer-assisted instruction will be felt in a very large number of school systems...

CONCLUSION

The use of computer technology in education presents a major challenge. Computers can reduce the drudgery of doing repetitive tasks in the class room tasks that are unadjusted and untailored to meet individual needs. The computer can free the serious student to go beyond teachers and books can give. There is every reason to believe that the wise development of computerized instructional systems will increase the intellectual experience of all students, and will permit the introduction of an almost unlimited sdiversity of curriculum. At the same time, educators can obtain unparalleled insight into the learning patterns of students.

REFERENCES AND BIBLIOGRAPHY

[1] Charles L. Aird, "An Investigation of Self-Study Computer-Based Instruction," *AERA* April 1974.

[2] Charles L. Aird, "The Instructional Uses of Computer Technology," Saudi Arabian National Computer Conference, November 1974.

[3] Charles L. Aird, "Computer Education for Saudi Arabia," Saudi Arabian Second National Computer Conference, November 1975.

[4] R.C. Atkinson and H.A. Wilson (Editors), *Computer-Assisted Instruction*, New York: Basic Books, Inc., 1965.

[5] William S. Dorn, "Computer-Extended Instruction," *Mathematics Teacher*, February 1970.

[6] Robert M. Gange, "The Learning of Principles," in *Analysis of Concept Learning*. New York: Academic Press, 1966.

[7] D.N. Hansen, "Learning Outcomes of a Computer Based Multimedia Introductory Physics Course," Florida State University CAI Center, 1968.

[8] Halen S. Hughes, "Gauss, Computer-Assisted," *Mathematics Teacher*, February 1971.

[9] John B. Keats and B.P. Hannenm, "Definitions and Examples as Feedback in a CAI Stimulus-Centered Mathematics Program," *Journal for Research in Mathematics Educations*, March 1972.

[10] Nancy Ledet and others, "Computer-Assisted Instruction Program at Tennessee State University," Stanford University, Institute for Mathematical Studies, 1973.

[11] Helen A. Lekan, "Index to Computer-Assisted Instruction," Sterling Institute, Boston, 1972.

[12] A.P. Mann and C.K. Brunstrom (Editors), *Aspects of Educational Technology*. Chicago: Education Methods, Inc., 1970

[13] Patrick Suppes and others, "Teacher's Handbook for CAI Courses," Technical Report No. 178, Stanford University, Institute for Mathematical Studies, September 1971.

[14] Patrick Suppes, "Computer-Assisted Instruction at Stanford," Technical Report No. 174, Stanford University, Institute for Mathematical Studies, May, 1971.

[15] Patrick Suppes, "Facts and Fantasies of Education," Technical Report No. 193, Stanford University, Institute for Mathematical Studies, October 1973.

[16] Patrick Suppes, "Computer Technology and the Future of Education," *Phi Delta Kappan*, April 1968.

[17] Karl L. Zinn, "Instructional Programming Languages," *Educational Technology*, March 1970.