Computer-Assisted Instruction: Many Efforts, Mixed Results

Computers have often been oversold as the solution to one problem or another, solutions that have never quite materialized. The educational use of digital computers is a case in point, for despite a great variety of more or less successful trials of computer-assisted instruction (CAI) on a small scale, the revolution in the classroom predicted by the most ardent proponents of CAI has yet to take place. Nonetheless, the results of recent trials and the scope and sophistication of some ongoing programs, including two major efforts to demonstrate the feasibility of CAI on a large scale, suggest that the computer may indeed come to play an important role in education, if more slowly than originally anticipated.

Computers have been used in recent years in primary education, in university classrooms, and in vocational and military training to accomplish a wide variety of purposes, ranging from limited assistance within or without the classroom to enrichment of the curriculum to total replacement of the teacher. There appears to be widespread agreement that computers have the capacity to facilitate individualized instruction and that their flexibility permits a variety of instructional strategies. Many believe that these machines have the potential to enhance the productivity of the individual teacher and improve the quality of the learning process. Questions of cost and institutional resistance to change are often cited as major hindrances to the use of CAI on on a broad scale. In addition, early trials of CAI have tended to make use of existing computer installations and programming languages, while concentrating attention on the development of the particular course at hand. Entire computer systems developed specifically for educational purposes have been rare, a circumstance that may have contributed to the problems of cost and acceptance in a substantial way.

Primary education is perhaps the most difficult challenge for CAI because of the importance accorded to the teacher-pupil interaction in primary schools. Hence the computer is usually considered as an addition to the normal educational experience, rather than as a replacement for the teacher. The costs of primary education with which the computer must compete are also low, relative to the costs of secondary and higher education. Nonetheless, computers have been used both to enrich primary education by providing opportunities for conceptual learning that are not available in the normal curriculum and to relieve the teacher from routine but necessary educational chores.

An example of enrichment in primary education is the work of Seymour Papert of the Massachusetts Institute of Technology (M.I.T.) and his colleagues. Their approach to CAI evolved out of earlier work in artificial intelligence, and the belief that, as they put it, "computation is intellectually rich." As such they reject the notion that CAI is merely automated programmed instruction; rather, they seek to have the child learn mathematical and other formal concepts informally through the experience of writing computer programs to control physical devices. One such device is a mechanical "turtle" (see Fig. 1), controlled from the computer by means of simple commands in Logo, an English-based language. In a typical project, students find out for themselves how to make the turtle draw polygons on the floor, thus learning, according to Papert a good deal about the abstract concept of angle and the principles of computational geometry. Although Papert reports an enthusiastic response from the small number of pupils with whom the approach has been tried, the net benefits are hard to assess by traditional means. Indeed, Papert talks of radical reforms of the educational process and of a time when computers will be inexpensive enough "for everyone to have one." With conventional computers and terminals, however, it appears likely that only well-to-do schools can consider such ambitious efforts; and, despite the apparent advantages of Papert's methods for assisting conceptual learning, mathematics and similar subjects constitute only a small part of what children are generally expected to get out of primary schools.

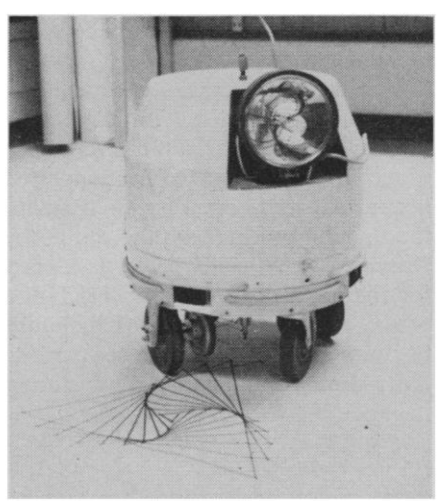

Fig. 1. A mechanical "turtle" developed by the M.I.T. Artificial Intelligence Laboratory. The turtle's motions are controlled with simple programs written by grade school students to explore geometric principles.

At the other extreme from the artificial intelligence approach to CAI in elementary schools are efforts by Patrick Suppes of Stanford University and his colleagues. Rather than seek to revise or add to the normal curriculum, they have used computers to assist elementary teachers with the more mundane aspects of teaching arithmetic. The computer drills large numbers of students for short periods each day (about 5 to 10 minutes per student) on arithmetical problems and keeps records of their progress. Psychological learning theories are used to optimize the amount of repetition and the difficulty of the exercises in ways that depend on the student's past performance, a practice that is possible because of the limited intellectual content of the material that is being taught. Relatively large numbers of students in grades 1 through 6 have been exposed to computer-assisted "drill and practice," and formal evaluations seem to establish that students do, on the average, learn more from the experience, but not much more than they would if conscientiously drilled by a teacher.

Between these two extremes, a great many other uses for the computer have been found. At a few universities whole courses have been taught by

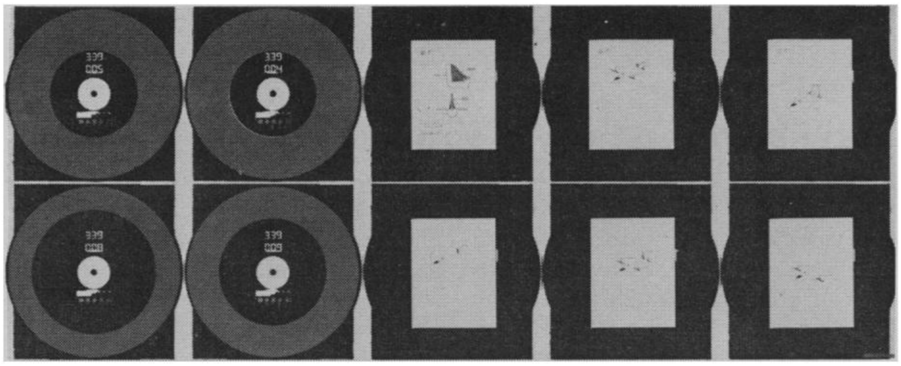

Fig. 2. A microfiche for a computer-assisted instruction system being developed for the Air Force by M.I.T.'s Lincoln Laboratory. In addition to diagrams and written text (barely discernible in the rectangular images), the microfiche contains audio information in the circular images. Each circle is essentially a short record describing the corresponding page of text.

computer, often with impressive results. At Stanford, for example, an introductory CAI course in Russian proved so popular that it greatly increased the enrollment in that subject; comparison with an identical course taught by traditional methods showed that students in the CAI course mastered more of the subject, and fewer dropped out. The less-talented students, in particular, seem to have benefited greatly from the more individualized instruction available from the computer. Despite large student demand, however, the CAI course was discontinued this year because it cost more than three times as much as one taught by an instructor.

More frequently, computers have been used at universities to teach part of a course—simulating market behavior for economics courses, or simulating a physical or chemical system for laboratory science courses. In some instances, computers have been made available to students for use out of the classroom as problem-solving aids and as adjuncts to more traditional instruction. At Dartmouth College, for example, about 100 computer terminals are available to students in dormitories and at other locations, and more than 90 percent of the 3000 undergraduates make use of the computer during the school year. The system includes several large collections of voting surveys, opinion polls, and other data, particularly in the social sciences, which students can examine and manipulate, in addition to solving numerical problems, generating computer art, or playing one of many computer games. Students at the Dartmouth business school are major users of the computer system for market studies, business games, and course work with financial data collections. Dozens of colleges and high schools in the New England area also have terminals connected to the Dartmouth computer.

One facet of the Dartmouth system that has encouraged wide student use of the computer is the ease of using the system—a simplified language, Basic, is the most commonly used—and its relatively high reliability. Complex computer systems of the time-sharing, multiterminal variety typically overload or experience other operating difficulties as often as every few hours. The Dartmouth system is able to handle as many as 160 simultaneous users, with failures less often, on the average, than once a day.

Vocational and technical training is also being attempted with CAI. The military in particular is a big consumer of technical training, and has supported several efforts to improve or expedite the training process with the computer. One approach that is being developed for the Air Force by F. C. Frick and others at M.I.T.'s Lincoln Laboratory in Lexington, Massachusetts, exploits the potential of microfiche for storing visual and audio course material (see Fig. 2). In connection with a small computer to control the progress of the course in response to student input, the microfiche system permits the display of detailed diagrams, large amounts of written text, and the instructor's spoken directions or comments without the need of a large computer memory. The computer is thus used primarily to manage the instructional process rather than to generate the course material or for its computational power. Field testing of the system by the Air Force is just beginning. Frick believes that the system will also be applicable to civilian vocational training and to some traditionally expensive types of public education—such as that for children with specific disabilities.

Despite the seeming vitality of efforts to develop CAI systems, as evidenced by the many diverse approaches to this goal, there remains considerable skepticism in many parts of the educational community as to the future role of the computer in education. Industrial firms with competence in CAI also appear to be adopting a "wait and see" attitude before making any further attempts to develop a market for CAI products. In addition to high costs, critics of CAI cite the prevalance of jury-rigged and unreliable systems, noisy and distracting terminals, and problems with transmitting CAI signals from computer to remote terminals over phone lines. Proponents of CAI admit these difficulties, but describe them as characteristic of first-generation efforts in a new field which they hope will be overcome with more experience. Indeed, many if not all of these problems may be resolved by two major attempts to demonstrate the efficacy of computer-based instruction—the Ticcet system being developed by the Mitre Corporation in collaboration with the University of Texas and Brigham Young University, and the Plato system being developed by the University of Illinois. In a second article these two systems, their differing approaches to the use of the computer in education, and their potential impact on educational practices will be discussed.—ALLEN L. HAMMOND