Computer-Assisted Instruction: Two Major Demonstrations

American education has come under heavy fire in recent years for failing to do its job. Rising costs and ineffective teaching have led to many proposals for change, including the suggestion that new technologies such as computer-assisted instruction (CAI) be employed on a massive scale. Partisans of computer-based education, which they regard as the most significant educational technology since printing, say that it has the advantages of individualized instruction and potentially lower cost, features that would be attractive to many a hard-pressed administrator. That a CAI system can function economically and effectively in practice, however, remains to be demonstrated.

Two attempts at such a demonstration, embodying rather different approaches to CAI, are now in preparation with $9-million support from the National Science Foundation. The Ticcit (time-shared interactive, computer-controlled information television) system is being developed by the Mitre Corporation in collaboration with the University of Texas and Brigham Young University. The Plato (programmed logic for automatic teaching operations) system is being developed by the University of Illinois. The 2-year demonstrations of these systems are to be independently evaluated by the Educational Testing Service of Princeton, New Jersey, under a separate $1-million contract.

The Ticcit system has the explicit goal of showing that effective CAI can be produced, packaged, and delivered economically, and that there exists a market for CAI, thus, as its developers hope, stimulating its widespread commercial dissemination. The Plato system has a similar aim of improving the productivity of teachers and the effectiveness of the educational process. Ticcit, however, is a decentralized system built around small computers along with a self-contained package of hardware, operating programs, and course materials for each school involved in the program. Color television is the display medium, and the system is primarily composed of commercially available components. In contrast, Plato utilizes a large, sophisticated computer in a centralized facility that will serve many schools; much of its hardware, including a new type of visual display for computer terminals, was developed especially for CAI.

The method of developing educational materials for use with these two systems differs even more greatly. The Ticcit program, headed by Kenneth Stetten of Mitre, has adopted a formalized method of developing CAI "courseware" through the collaborative efforts of teams of programmers, educational psychologists, and specialists in the subject of the course. The Plato program, headed by Don Bitzer of the University of Illinois, espouses a more ad hoc approach of letting teachers design their own courses with the aid, if necessary, of the Plato staff.

The cost of computers has been dropping in recent years, and is expected to continue to decrease—a trend that is often cited by CAI proponents. The Ticcit project, however, hopes to demonstrate that low cost CAI is possible with existing small computers, and, moreover, that it is possible to combine the computer with color television technology. The system as currently planned will consist of two interconnected minicomputers that are capable of serving at least 100 student terminals. The computers will operate as a time-sharing system, responding to a student's terminal within about 0.5 second. The terminals are attached directly to the computer or are remotely connected through cable television channels, and they consist of color television receivers, headphones, and a keyboard. The television sets can display graphical or printed material generated by the computer or short videotape films. Audio information is stored on random access record players that are controlled by the computer. The lesson materials will be stored on large disk memories.

One problem that has hampered the use of television in CAI systems is the awkwardness of converting digital information from a computer to the continuous electronic signal required by the cathode-ray tube. In past systems, a television picture transmitted to a given terminal was sometimes mechanically stored on a videotape and replayed to "refresh" the television screen every few milliseconds. In the Ticcit system this operation is performed with a small integrated circuit memory attached to each terminal—a design that until recently would have been prohibitively expensive (the memory is still the most expensive component of a terminal).

A side benefit of having most terminals directly connected to the computer by a cable is that the pictures on these terminals will have sharper images than those of ordinary television. The terminals will display up to 17 lines of 43 characters, each of which can be specified by the programmer, thus allowing the use of special symbols. The color of the written text or of the background can also be specified, thus allowing some colorful and unusual combinations. The terminals are serviced by one of the two computers, while the other does most of the actual processing of student answers; on the basis of simulated experiments, the Ticcit team believes that new educational material will need to be generated about every 10 seconds for each student, and is designing the operating programs for the two computers accordingly.

Perhaps the most significant innovations of Ticcit are the course material itself and how it is produced. The traditional methods, in which preparation of a course is the responsibility of an individual teacher or a textbook author, are not used; rather the Ticcit courses, which are being developed under the direction of Victor Bunderson of the University of Texas, are designed, pretested, and programmed for the computer by teams of specialists. The effort is calculated to demonstrate that an industrial approach can replace the teacher as the source of instructional material, and the courses are presented so that the teacher will be a counselor or diagnostician, and in some cases might even be substantially eliminated.

The Ticcit lessons offer the student several options for ways of learning—for example, the choice of an initial overview of the material—and allow him considerable freedom as to the order in which he completes the lessons, his rate of progress, and his handling of auxiliary material such as films. The Ticcit courses are based on the assumption that the student's attitude is much more positive when he has control over his own learning process. Borrowing from the approach developed for television by the Children's Television Workshop (the originators of Sesame Street), Ticcit also attempts to increase the student's motivation and interest by including humor, cartoons, and other touches of fun in the learning experience.

The initial trial of the Ticcit system will be in junior colleges, which seemed a likely market because of their relatively few basic courses and the typically wide range of student abilities, for which individualized instruction would be especially useful. Four courses—freshman English and mathematics, and remedial versions of each of these—will be taught for a 2-year demonstration period beginning in 1974. The goal of the effort will be to displace as much as 20 percent of the traditional teaching load at two separate junior colleges.

Because the system is not yet operational, however, the Ticcit team has not been able to test out its complicated operating programs or to gain any experience with the hardware, so that its reliability and the existence of any unexpected problems remain to be determined. Reliability will be a key part of the system's success or failure, because it is intended that the hardware, the operating programs, and the course materials will be sold as a self-sufficient package; backup support would be available from the Mitre team, but Stetten claims that a school need hire no more than a single technician to operate and maintain the system. This goal—in comparison with the constant attention of several professionals which is necessary to keep most complex computer systems operating—appears to many computer scientists to be unrealistic.

Stetten estimates that the initial Ticcit system with 128 terminals will cost about $400,000, although that price does not include the expense of producing the sophisticated course materials that it will use. Nonetheless, the estimated cost is low enough to be within the reach of many junior colleges, and at about 35 cents per student per hour is well below the current junior college average for instructional expenses. If the system achieves its intended capabilities, it will be an attractive possibility for small schools and where limited numbers of standardized courses are taught. Stetten believes it will also prove attractive to large schools and, eventually, to home users as an adjunct to cable television systems.

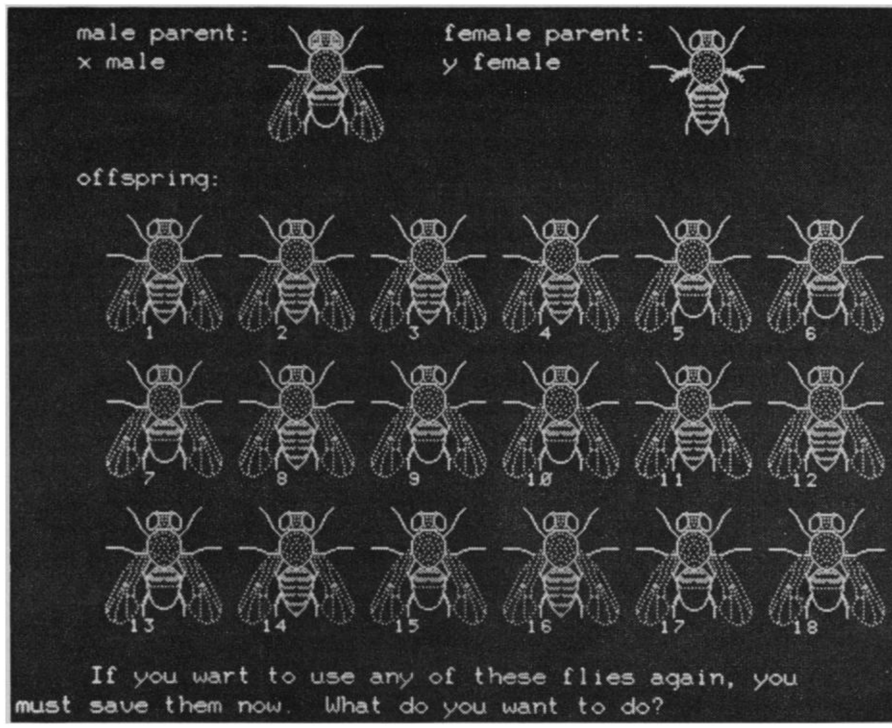

Fig. 1. A display generated by computer on the Plato plasma panel. In this genetics course, students simulate the classical Mendelian experiments with fruit flies by breeding successive generations to develop mutant strains. Students observe the ways in which mutant characteristics are inherited, and conduct their own experiments.

Where large numbers of students and many differing educational roles must be accommodated, however, a more flexible system has some advantages. Compared to Ticcit, Plato is a much larger, more elaborate, and possibly more expensive system, which is the result of almost 13 years of development. Based around a large computer—the Control Data Corporation (CDC) 6400—the system is intended to have four central processors and to serve, at any one time, as many as 4000 student terminals located anywhere within an 800-mile range of the computer. The Plato system is thus one of the most ambitious time-sharing systems ever attempted. Much of the hardware, a new programming language adapted for teaching, and economical new techniques for linking remote terminals to the central computer were designed specifically for educational use; the designs were based on substantial experience with earlier versions of Plato, including more than 100,000 hours of CAI instruction in grade schools, community colleges, and university classrooms.

The student terminals in the Plato system are perhaps the most sophisticated devices ever developed for communicating with a computer; not surprisingly, they are also its most expensive component. The terminals consist of a plasma display panel on which visual information is shown, its associated electronics and connections to a telephone line, a keyboard, a random-access slide projector, and various accessories, including a random-access audio device that can both play and record and an infrared sensor system that responds to the touch of a finger on any part of the visual display.

The plasma panel, unlike a television tube, can display graphic information permanently without auxiliary storage equipment. It is an inherently simple device, consisting of thin, flat, glass sheets in which two fine-wire grids are embedded. A gas contained between the sheets is ionized when an initial voltage is applied to selected points of the grid, and the ionization is sustained by a weaker alternating voltage applied to the entire grid. Since graphic information can be specified point by point or line by line for the entire 512 by 512 grid, the system provides extremely sharp images and can utilize virtually any type of characters (see Fig. 1). The panel is transparent, so that color slides can be superimposed on information generated either by the computer or by the student; motion pictures can also be shown on the panel but have not normally been included in Plato courses.

The Plato hardware is generally acknowledged to be an extremely flexible system, capable of remarkable feats. Although the terminals are linked to the computer over ordinary phone lines, the terminals provide elaborate graphical displays; they can write at the rate of 180 characters per second, and the computer responds to a terminal within 0.1 second. For remote terminals, the signals for as many as a thousand terminals can be transmitted through a single educational television channel at a great reduction in cost.

Less widely known are what appear to be equally remarkable innovations in the operating programs and software for Plato. The system makes use of unique storage features of CDC computers which allow very rapid access to blocks of stored information, so that no use is made of slower, mechanically driven disk memories during a lesson. The status of all students who are "on line" as well as the materials for several hundred different lessons are thus stored directly in the computer. Only one user is served at a given moment, however, and that service is completed before the next request is handled. The result is that almost the entire computational power of the computer is available to the student. To preserve efficiency, the Plato programs avoid symbol manipulation, and to conserve memory they try to generate desired information by computation rather than by storing large amounts of material.

For authoring new courses, a programming language (Tutor) based on English grammar and syntax is designed for use by teachers with no knowledge of computers. Some 200 such teachers of varying backgrounds have created courses with Tutor on earlier versions of Plato. Tutor includes special methods of generating graphical displays, of preparing dialogues between the student and the lesson, and of judging student replies; the system can distinguish, for example, between a slightly misspelled answer (which it accepts as correct, but informs the student of the correct spelling), a wrong answer (anticipated by the teacher), and an answer it does not recognize. The language automatically arranges material for display on the plasma panel, and it includes clever methods for searching long vocabulary lists at high speed.

The Plato approach is an attempt to improve the productivity of teachers rather than to replace them, an approach that may meet with less resistance from the educational community than that of the Ticcit approach. The experience with a Latin course taught at the University of Illinois with an earlier version of the system illustrates what the Plato team hopes to achieve. After converting his course to the computer, the Latin professor found that he could handle a class of 60 students, a fourfold increase over the normal 15. Furthermore, he discovered that he could bring essentially all of his students to the desired level of mastery of the language, while covering some 30 percent more material than usual. Student response to the course was so enthusiastic that enrollment doubled the following year. On a larger scale, Daniel Alpert, dean of the graduate college at the University of Illinois, points out that one fully utilized Plato system will be able to provide 10 million hours of instruction per year, an amount that could increase the enrollment of the Illinois state educational system by 20 percent for a cost of less than 2 percent of the state's education budget. For this reason, the Plato system has attracted considerable attention from state officials there, and as a result they are providing roughly half of the funds to support its demonstration.

With a full complement of 4000 terminals, the estimated cost of Plato, including managing the system, producing lesson materials, and communication charges, is about 50 to 80 cents per hour per student, according to Bitzer. For the 2-year demonstration period that begins in the fall of 1973, however, only 500 to 1000 terminals are expected to be available, and consequently the initial costs will be substantially higher. More than half is attributable to the cost of the terminals, and Bitzer expects that with experience and with mass production this might be considerably reduced, since none of the terminal components are inherently expensive. The estimates are based on the assumption that the central computer will be used for instruction only 40 hours a week, and that the remaining computer time could be sold to reduce expense or used, as the Plato team intends, for educational research. Despite the high total costs of the system (the computer itself is estimated at $5 million, and each terminal at about $5,000), the initial investment for a school wishing to experiment with CAI is relatively low, about $60,000 annually for a single classroom of terminals attached to the Plato computer.

The Plato system is intended by its developers to be used in all sectors of education, from primary schools to community colleges to universities. The Plato team believes that their system is not committed to any single educational approach, but could usefully augment any teaching strategy; and in contrast to the professionally produced course materials of Ticcit, the developers of Plato prefer to rely for the most part on the individual teacher. "Given this flexibility [of Plato], only a dull teacher doesn't have ideas about how to use it," one staff member put it. This claim is the more impressive for being documented by data from courses taught for several years with previous systems and several months of experience with the prototype Plato IV system.

In one course for grade school children, originally designed by computer scientists at the Massachusetts Institute of Technology, Illinois students using Plato explore by trial and error the motions of a man balancing a stick, eventually discovering the effects of overcorrection and the principles of dynamic balance. At the other extreme, in an advanced laboratory course, organic chemistry students at the University of Illinois use Plato to "pre-run" their experiments with computer simulations so that they understand the conceptual basis of the experiment and become aware of the choices, potential mishaps, and phenomena that they are likely to encounter before they ever enter the laboratory. For all courses, the Plato system provides the teacher with the capability of live or retroactive monitoring of class performance, computing summary data on the whole course, so that the teacher can see what tasks were taught efficiently, the number of errors, and the length of time required.

Both Ticcit and Plato groups have received numerous inquiries from schools that are interested in participating in the demonstration effort, suggesting that not all educational institutions are as resistant to CAI as had been expected. The impending demonstration of these two systems will not bring about the use of the computer in the American classroom overnight, nor are they likely to convince the many critics who believe that the answer to educational reform does not lie in new technology. But taken together, the Plato and Ticcit systems seem likely to have a substantial impact on education in this country.—ALLEN L. HAMMOND