Computer Center

CIBE Systems

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Many topics appearing in *ABT*'s Computer Center will concern standalone microcomputers because many bioeducators have access to them. But it is important that we maintain a broader perspective of the diversity of available CIBE (Computers In Biological Education) systems for two reasons: many other systems than standalone microcomputers are in use in CIBE today; and as CIBE use grows, educators, departments, and schools that have previously used only standalone microcomputers may benefit by adopting another type of system.

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For use in The Computer Center, Ted welcomes suggestions on what subjects should and should not be treated, summaries of educational computing centers, innovative uses of computers, and information about relevant books and events.

Before expanding the classification of types of computing systems, let's consider some important concepts. *Computer system* is a general term. It refers to any combination of hardware, software, and people. Of the infinite combinations of hardware, software, and people that can be imagined, some may be physically impossible. Of those that are possible, some computer systems (not just hardware) may be totally unable to fulfill a particular task, while others could fill it very well. A *CIBE system* is a computer system with an intended use in biological education. An example is the combination of a particular maple species identification program available on an Apple II computer and targeted for a college-level General Biology course. As such, this CIBE system might be of little value for a high school or advanced college course. A *CIBE module* is a CIBE system which is actually integrated into a particular course at a particular school with a particular teacher and type of student in mind. An example would be the use of the particular maple program on an Apple II system in the Freshman General Biology course at The University of Notre Dame. A *CIBE event* is an actual use of a particular CIBE module in a particular course at a particular school, etc. For example, the use of that particular maple program in General Biology 104 at the University of Notre Dame in Spring 1982.

Some readers may question the need for the separate terms *computer system*, *CIBE system*, *CIBE module*, and *CIBE event*. But close reflection indicates that each term defines a different concept. When just beginning to use CIBE, a bioeducator may not need to distinguish among any of the concepts. But with increased use of CIBE such distinctions become useful and even essential. For example, it is essential to consider CIBE events when carrying out meaningful statistical evaluations of the effectiveness of a particular CIBE module. Similarly, a specific set of CIBE modules must be considered when choosing a particular CIBE system for a course or an entire biology department.

The distinction between the terms *computer system* and *CIBE system* is mostly in the type of software used and the organizational context in which the system is found. The following classification of CIBE systems thus is equally appropriate when considering computing systems in general, and not just in a bioeducation context.

1. The *standalone, single user, microcomputer system.* This is fast becoming the most popular type of CIBE system. An example is the maple specimen identification program on an Apple microcomputer discussed above. Another is using the program, NOMEN, on a Radio Shack computer. NOMEN teaches the users the rules of botanical nomenclature. Some standalone, single user, microcomputer systems have been developed primarily to

accumulate data automatically from some laboratory instrument. An early example is the MINC (Modular Instrument Computer) designed around a Digital Equipment Corporation LSI-11/2 microcomputer. It is equipped with several ports to allow laboratory instruments to be easily interfaced to it. But several general purpose microcomputers now also can often serve this purpose well and, when not being used in the laboratory, can serve in other courses. For example, at Notre Dame the laboratory associated with the Introductory Physiology course is replacing its expensive Dynagraph recorders with inexpensive TRS-80 Color Computers. The Color Computer can do all that is required of the Dynagraph, but it also can process the data of an individual student, efficiently pool data from each of the students in the class, and even compare this year's data with those from past years! Just as important, one Color Computer costs less than half the amount to repair one of the Dynagraphs.

2. The *standalone, single user, microcomputer and videodisc system.* While it is still premature to describe actual examples of their use in CIBE, their potential is great, and they will provide serious competition for educational uses of multimillion dollar computer systems such as the PLATO system to be discussed below. One videodisc can store up to 50,000 2×2 projection slide images, enough for an educator to choose a unique set of slides to enhance every lecture. Even more exciting is the development of interactive videodisc systems which will allow storage on the same disc of slide images, moving picture sequences, audio, data, and programs! The January 1982 issue of *Creative Computing* has several informative articles on videodisc technology. (As an aside, common usage now spells videodisc with a "c," but spells the other type of computer storage disks and their disk drives with a "k.")

3. The *standalone, multiuser microcomputer* or *minicomputer system.* These have been available, and are often a logical step when the sophistication of one's use of computers in education increases. As long as each user needs relatively little computer resources (e.g., only available main memory found in each microcomputer), then multiuser computer-based systems may not be advantageous. As user needs increase, such as when the size of a computer program increases, or a large data set must be accessed, then the need increases for such multiuser microcomputer-based systems. But even before such more sophisticated needs arise, a multiuser, microcomputer-based system may be cost effective. Consider the situation where students in a course have access to six standalone microcomputers. Their task is to review a series of multiple choice questions, or perhaps to carry out a simulation of a biological system. Each of the standalone microcomputers would require its own storage system, be it a cassette tape and recorder, or a disk and its associated disk drive. Assuming the systems are disk-oriented, this would require the purchase of six disk drives. In contrast, if the microcomputers were connected to each other in a multiuser system, only one disk drive might be needed. For example, in the Chemistry Department at The University of Notre Dame, students carry out certain laboratory assignments in Inorganic Chemistry and Introductory Organic Chemistry by using an Apple computer. Sixteen Apple computers are located in one room, but only one disk drive is used. One of the Apple computers is the "queen," while those remaining are "slaves." Since only one program is needed at a time by all users, the queen is the only one that requires a disk drive. In loading the program, each of the slave computers is treated as an output device. The relevant program is simply downloaded to each slave computer, one at a time. The important points are not only the savings on disk drive purchases, but also the fact that the conversion of 16 individual Apple computers into one microcomputer-based system was possible with the construction of a simple electronic black box for under $200.

More sophisticated multiuser, mini- or microcomputer-based systems are available than this queen/slave example. They may offer procedure-oriented languages such as BASIC, problem-oriented languages for word processing, data analysis, etc., and permit each user to work independently. Most computer companies offer printed descriptions of multiuser configurations which emphasize their use for education.

Perhaps the best known example of a standalone, multiuser, minicomputer-based system is TICCIT (Timeshared Interactive Computer Controlled Information Television). It was developed by the Mitre Corporation in collaboration with both The University of Texas and Brigham Young University. In addition, the TICCIT system has received multimillion dollar support from the National Science Foundation. It is a decentralized computer system which uses small computers. Each has a self-contained package of operating programs and courseware. The television sets in the TICCIT system are connected to the small computer for two-way exchanges between the computer and the students. Videotapes also can be used to produce moving pictures on a student's terminal. The original market for TICCIT systems was junior colleges and community colleges. But other industries, including the Defense Department, have become interested in its educational value. TICCIT is a rather specialized system and appears not to possess many capabilities of recent standalone microcomputer systems. In particular, the growing availability of microcomputer systems with videodiscs may well remove any advantage that the TICCIT system has. As in several other cases, the historical perspective is extremely important. The TICCIT system was championed (and supported by the National Science Foundation!) as an effective computer-based educational system at a time when videodiscs were unknown.

4. The *standalone multiuser maxicomputer system.* These (or super-minicomputer-based systems) often are found on a college campus. Until the arrival of minicomputers and particularly of microcomputers, this has been the standard computer system for timesharing. With its immense storage capacity, its ability to serve many users at the same time, and its great diversity of software, this can be the ideal computer configuration for CIBE. But it does have its drawbacks, including high cost, often-poor response time between computer and user, and competition between teaching, research, and administrative uses. Examples of CIBE uses of such a system at Notre Dame include the storage, retrieval, and analysis of data obtained in laboratories in aquatic biology courses, multiple choice course review, simulation of endangered species and of world agriculture, and specimen identification.

Sometimes the multiuser, maxicomputer system includes many users at remote sites which are not all on one campus. Examples include the PLATO (Programmed Logic for Automatic Teaching Operations) system. PLATO was one of the first CIBE systems in which the computer was not on the same campus as the students using it. The PLATO system was begun at the University of Illinois and over the years has received multimillion dollar support from the federal government. It was begun in cooperation with CDC (The Control Data Corporation), a large maxicomputer manufacturer, and continues now as a joint commercial venture of CDC. In the early 1970s it was presented as the ultimate in computer-based education. Large amounts of educational software have been written for it, much via TUTOR, an authoring language. It has many capabilities, including those which are particularly attractive to biologists. One of the better known examples is its fruit fly experiment program. The program is very appropriate for an introductory biology or genetics course. For example, in one exercise, realistic fruit flies are presented on a graphic screen called a plasma panel. The resolution is sufficiently high such that individual mutants can be identified. Students then are asked what they would like to do. For example, if they wish to cross two particular flies presented on the screen, they simply indicate it by physically touching the part of the plasma screen displaying those two flies. Then (assuming the flies chosen are of the opposite sex!) the resulting offspring are presented on the freshly erased screen. From such crosses and their statistical analyses (which PLATO again provides after simple request), students quickly carry out many more crosses than would be possible if real organisms were involved.

Naturally, not every week of genetics laboratory should be computer oriented. The problem with the PLATO system for use in bioeducation has been its cost. Costs have remained at between $5,000 and $10,000 for the purchase of a PLATO terminal. But its plasma screen terminal is a fantastic device. Besides allowing communication with the computer by either touching part of the screen or the keyboard, it can display pictures stored on microfiche, etc. The terminal itself now is available as part of a standalone microcomputer-based system, thus providing independence at a reduced cost. We can also expect that a system with such a terminal and a videodisc will soon be available.

5. The *local computer network system.* All of the above CIBE systems involve only one computer (one "mainframe"). But computers themselves can be linked together via communications networks. Such computer configurations are often said to possess *distributed processing* capabilities. A *local* computer network is one in which the several computers are located relatively close to each other, e.g., on the same campus or even in the same building or large room. For example, the campus maxicomputer can communicate with an intelligent terminal. The latter in fact is a microcomputer which can either preprocess or postprocess information being sent to or received from the maxicomputer. Preprocessing may involve the calculation of observed gene frequencies for repeated experiments by each student in a class. Perhaps only the average values are to be sent to the large computer for integration with previous year's studies and the use of a sophisticated problem-oriented statistical and graphics program like SAS. Postprocessing by the microcomputer may involve the storage of certain ecological data selected from a much larger data base that can only be efficiently stored on a maxicomputer. The selected data will be used on the microcomputer as input for an ecological simulation performed in the ecology laboratory. These examples indicate the essential character of a distributed processing system: actual computer processing uses more than one computer's central processing unit; i.e., the processing is distributed. Depending on the computing network, a user may not be aware of which computer is being used to process his or her job.

6. The *long distance computer network system.* These often involve several maxicomputers at separate sites, each of which may have a sub-network of other maxicomputers, superminicomputers, or minicomputers. These in turn may involve a network of microcomputers which control other microcomputers and terminals

(gasp!). Communication between any two of the variety of computers may be by regular telephone lines, dedicated lines, or even by a communications satellite. Long distance computer networks have existed for over a decade. Among the most familiar types for computer-based education are those involving statewide educational networks. Advanced networks are found in such states as Minnesota, Georgia, and California.

Perhaps the most widely known example of long distance distributed processing in education is EDUNET, an activity of EDUCOM (P.O. Box 364, Princeton, NJ 08540). The underlying philosophy of EDUNET is to simplify the use of specialized computing resources available at 15 EDUNET suppliers (e.g., Stanford, Notre Dame). EDUNET has over 100 user institutions. They represent large and small, private and public, teaching and research-oriented institutions across the country, including some school districts. The advantage of a long distance distributed processing network like EDUNET is that if biology educators know a valuable program exists at one of the 15 institutions, they do not have to purchase the program and attempt to make it compatible with the computer in their own departments or campuses. Another reason for bioeducators (and researchers!) to use EDUNET is that many of the programs, because of their size and capabilities, are revised frequently with the result that mistakes are eliminated, programs are made more efficient, and new options are added. Consequently, even if a bioeducator had the time and expertise to initially adopt a program to his local machine, he would periodically still have to devote time and other resources to purchasing and installing updated versions. In such situations, limited use of a computer network may prove cost effective.

In our discussion so far, little has been said about the software and people involved in each of the computer systems. Naturally they are essential, but also can be quite diverse even within each type of system, due to the actual context in which a bioeducator is located. These topics will be considered later in The Computer Center.

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