Chapter 5

DEVELOPMENT AND DISSEMINATION OF COMPUTER-BASED EDUCATION

5.

DEVELOPMENT AND DISSEMINATION OF COMPUTER-BASED EDUCATION

OVERVIEW

This chapter describes the extent of development, use, and dissemination of the computer-based educational materials discussed in the previous chapter. The institutions described in this chapter were selected to represent a variety of institutional developers and users of health sciences computer-based education (CBE) materials. Each institution applies computer technologies differently and possesses a range of computer hardware, software, and mechanisms by which users access computer-based materials.

Three centers that have different types of CBE are described in this chapter: the Ohio State University College of Medicine, the University of Illinois School of Basic Medical Sciences, and the Massachusetts General Hospital. The Ohio State CBE system serves most health areas, including nursing and allied health. The University of Illinois center uses one of the most sophisticated CBE hardware systems and concentrates CBE use in the basic medical sciences. The Massachusetts General Hospital has a hospital-based program focusing on clinical applications.

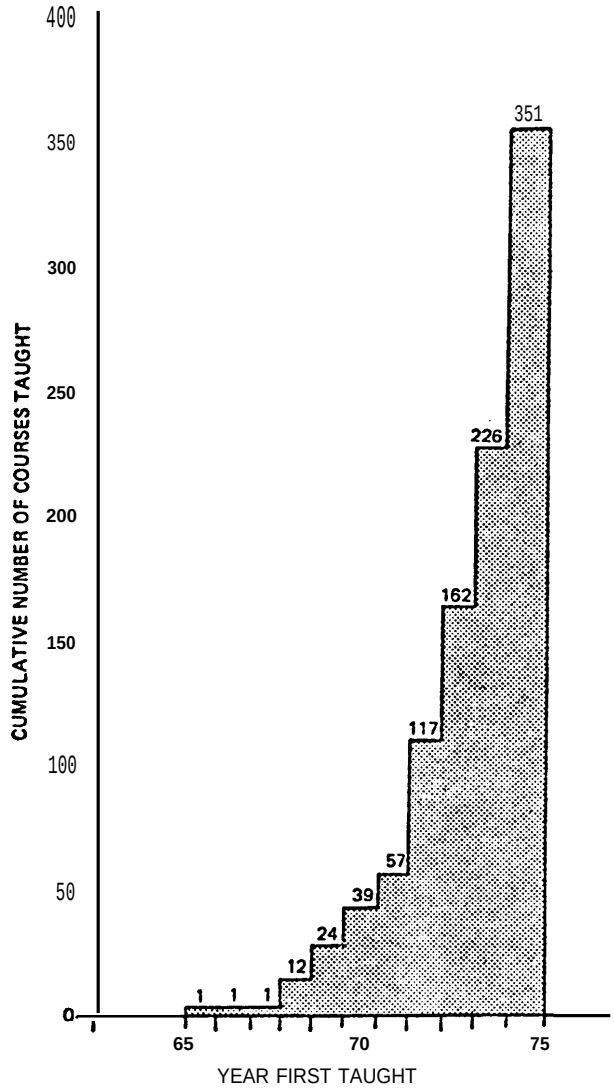
The methods of disseminating CBE materials are described in the second section of this chapter. These methods represent both *on-line* and off-line methods of sharing. In off-line dissemination, CBE courseware is transferred to the users' computer; in on-line dissemination, CBE courseware is made available to the user by networking or some other form of communication. The Health Education Network, Inc., is one example of on-line dissemination; the Computer-Assisted Teaching Systems Consortium and Milliken Communications Corporation are examples of two different off-line sharing methods.

INSTITUTIONAL DEVELOPMENT AND USE

During the past decade, the development and dissemination of computer-based educational and assessment materials in the health sciences have been rapid. In *80* American and 4 Canadian institutions that responded to a 1975 survey of the 135 U.S. and Canadian medical schools (Lefever and Johnson, 1976; Tidball, 1976), there was at least a 60-percent annual growth rate, since *1967,* in the number of medical school courses using CBE. Figure 12 shows the cumulative number of such courses versus the year in which they were first taught. The 351 courses taught in 1975 were divided almost evenly between the basic and the clinical sciences, These courses were developed using more than 15 different types of computers and programing languages.

Of the 84 schools that responded to the 1975 survey, 69 percent generated programs at their own institutions, and 64 percent used programs from other institutions via networking or time-sharing arrangements (an institution can both create its own programs

Figure 12.—Cumulative Number of Courses Involving CBE Versus the Year in Which They Were First Taught



SOURCE Tidball, 1976

and use those of any number of other institutions). Fifty-one percent of the institutions reported having permanent facilities for computer-based instruction.

The critical factors that facilitate or inhibit the development or use of CBE in the institutions described in this chapter are the following (Casburgue, 1978):

- the high financial investment required for the development of CBE is a primary inhibiting factor to use;
- a reliable computer system is an essential prerequisite for CBE development or use;

- an institutional commitment must be made not only to the development and use of CBE, but also to the provision of support staff;
- educational programs must be available for faculty administrators and technical personnel; and
- the degree of CBE integration with other instructional modalities is an important determinant of its use.

Table 9 ranks the top 10 medical institutions according to both the number of CBE course hours and the number of CBE programs or units they have produced. * Three of the institutions are described below.

Table 9.—Institutions Producing Computer-Based Materials

Ten most productive institutions (by course hours)		Ten most productive institutions (by number of programs)	
Institution	Course hours	Institution	Programs
Ohio State. 229		Ohio State. 63	
Illinois 58		Cornell. , ... 33	
Pennsylvania State. 58		Massachusetts General Hospital. 27*	
Kansas. 52		Purdue. 21	
U.S. Army 39		California (SF). 16	
Massachusetts General Hospital. 36		Michigan 14	
Florida. 25		Harvard 10	
British Columbia 25		Northwestern 10	
California (Los Angeles) 19		Connecticut 9	
Cornell 17		Missouri (Kansas City) 9	

. Each of these basic programs can create multiple cases so that over 200 different learning situations are available
SOURCE Kamp, 1975

The Ohio State University College of Medicine

The largest collection of available CBE courseware in medicine and health-related areas resides at The Ohio State University (OSU) College of Medicine (Kamp, 1975). This CBE system has grown from a one-terminal, one-course system in 1967 to a system that provides 22-hours-per-day, 7-days-per-week CBE access for students and health professionals throughout the United States; maintains a program library of over 425 interactive hours of CBE materials; logs approximately 3,000 usage hours per month; and adds CBE course materials to its library at the average rate of 5 interactive hours per month (Pengov, 1978).

The computer has been an important element at OSU in undergraduate medical education, nursing education, allied health education, continuing health sciences education, and patient and nonmedical support staff education. It is used both to assist in instruction and to help manage the instructional process. Every medical and nursing student in the college uses the computer. A smaller but significant percentage of allied health students also uses the computer.

In the traditional lecture-discussion curriculum, as in the independent study program (ISP), computer-assisted instruction programs are rather extensively employed. Fifty-two CBE programs are used by medical students in this curriculum; each student spends a minimum of 25 interactive hours at the computer terminal. The most extensive use of CBE is in physiology; CBE tutorial units parallel class lectures and readings on physiology. Since 1973, the college has refined, developed, and used the computer-

*There are other producers of CBE medical materials (e.g., the Air Force) that are not described in this table but are described elsewhere (Deland, 1978).

assisted simulation of the clinical patient encounter (CASE) (Pengov, 1978). The model, a natural language simulation of the patient-physician encounter, is used on an elective basis by students in the clinical areas.

The School of Nursing's Bachelor of Science curriculum includes more than 35 interactive hours of CBE materials that are used in a variety of ways by over 600 nursing students. Eight CBE programs, representing *20* interactive hours, are required of all nursing students; 7 CBE programs, 15 interactive hours, are used as optional, supplemental learning materials (Mourad and Forman, 1976).

The degree of CBE integration into the curriculum of the 11 divisions in the School of Allied Medical Professions varies by division. Six divisions do not use CBE; others use 40 CBE programs in approximately 20 required courses. Student involvement with CBE varies from 4 hours in radiation therapy to over 100 hours in medical dietetics (Breeze and Schimpfhauser, 1976).

During 1968, a pilot network, designed to provide continuing education to Ohio physicians, was established and placed in four community hospitals chosen to represent various geographical areas of the State. The goals of this project were revised in 1970; other health professionals were included, and the network was expanded to *10* hospitals within the State. Federal subsidies to the hospitals for program development declined between 1970 and 1975, and, as a result, 18 institutions began to pay the full costs of using CBE through OSU's Computer-Assisted Instruction Regional Education Network (CAIREN) (Forman et al., 1978).

Throughout its history, CAIREN has attracted some 29 institutions to its membership roles. The CAIREN membership has fluctuated according to the educational needs of each member institution; membership has also changed for reasons of cost. Membership has ranged from 1 to 7 years, from small community hospitals of less than 300 beds to large teaching hospitals of nearly *1,000* beds, and from mental institutions to health-related educational institutions and to technical schools offering nursing and allied health training programs. Table 10 summarizes the membership profile during CAIREN'S first 10 years.

The institutional libraries of most CAIREN users have a terminal that provides access to CBE materials. CAIREN avails CBE to hospital personnel on all shifts, every day of the week, for both in-service training and orientation programs. CBE continuing education courses are accredited for use in Ohio by the professional societies listed in table 11.

Table 10.–Computer-Assisted Instruction Regional Education Network (CAIREN) Membership Profile

Year ending	Number of members	Institution type: Community hospitals	Institution type: Health-related educational facility	Institution type: Mental health institution	Hours of use
1969	4	4			— —
1970	12	12			— —
1971	13	12	1		— —
1972	19	15	4		8,536
1973	16	12	4		13,300
1974	20	10	4	6	11,374
1975	15	8	3	4	8,430
1976	9	8	1		6,220
1977	8	7	1		4,164
1978	12	7	5		4,326

SOURCE: Ohio State University College of Medicine.

Table 11 .—Accreditation of Computer-Based Continuing Education Courses by Professional Societies

Professional society	Approximate hours of CBE credit available
American Dietetic Association	108
American Medical Association	70
American Osteopathic Association	All programs eligible for Category II-A credit
Ohio Council of Medical Technology	60
Ohio Nurses Association	6
State of Ohio Board of Pharmacy	106

SOURCE Pengov. 1978

As a direct result of the continuing education efforts, courses have been developed for use by nonmedical support staff and patients. Courses on the medical record and on medical terminology are examples of two support staff courses that have been useful in CAIREN hospitals. Examples of CBE patient courses include those that offer instruction to mothers in the care and feeding of newborns, allow patients to assess the probability of heart attacks, and provide guidance on proper menu planning. The variety of audiences that use the college's CBE materials is shown in table 12.

The college's CBE materials are available to users via two routes. In the first, "off-line, " the CBE programs are removed from the OSU computer and put in the user's computer. Over 100 C-BE programs have been transferred "off-line" and are used largely on compatible IBM equipment using COURSEWRITER III programing language. In the second and more heavily used route, the user has a terminal onsite but links via telephone lines to the CBE data base at OSU. The extent of CBE use at OSU has been influenced by the ability of one integrated data base and CBE hardware system to service a wide variety of users. CBE use also has been influenced by the large numbers of support staff whose existence minimizes the extent to which faculty authors must learn about computer operations. Figure 13 delineates the three major user groups: the college's own educational programs, the statewide sharing network (CAIREN), and the nationwide Health Education Network. * Table 13 provides data on the three groups of users. Figure 14 shows the breakdown of the use by the College of Medicine itself, and table 14 summarizes this use over 6 years.

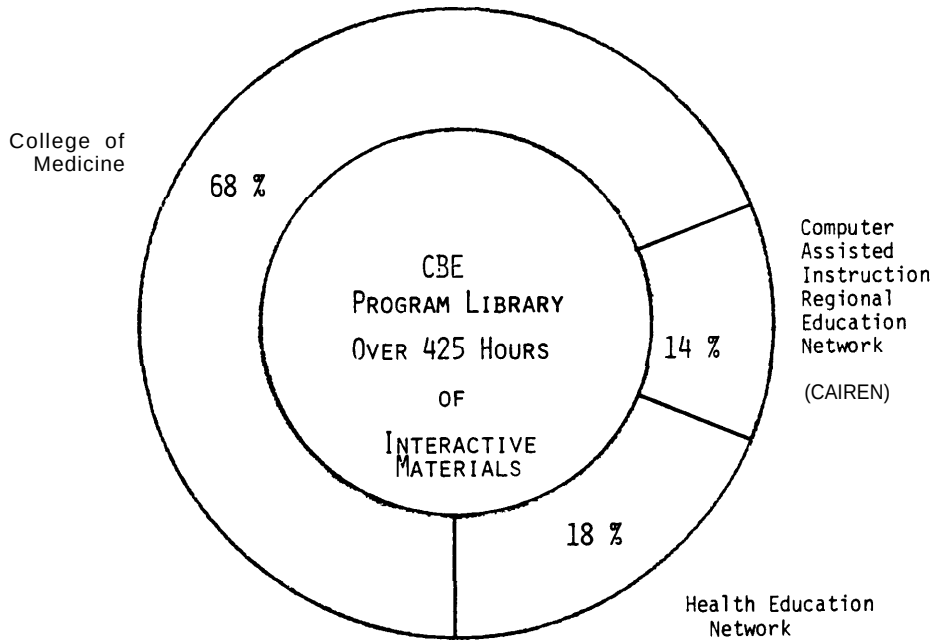
Table 12.—The Ohio State University College of Medicine Computer-Based Education Programs Indexed by Audience

Audience	Number of programs
Clinical laboratory	27
Dietary	26
Dental	6
Emergency medical	14
Environmental services	8
Management	6
Medical records	8
Medical (physicians, residents, interns, students)	113
Nursing	51
Occupational therapy	18
Optometry	5
Patients and families	**10**
Pharmacy	6
Physical therapy	20
Respiratory	15
Radiology	17
Secretarial	11

SOURCE Pengov, 1978

*This is a network for interinstitutional sharing of CAI materials described later in this chapter.

Figure 13.—Data Base and CBE System User Group Overview



SOURCE. The Ohio State University, 1978

Table 13.—College of Medicine Computer-Based Education User Group Summary

Category	Number of terminals	Average usage hrs./month	Total usage[b]
College of Medicine	24	1,728	20,738
Computer Assisted Instruction Region Education Network (CAIREN)	9	347	4,164
Health Education Network	39[a]	348	4,174
Totals	72	2,423	29,076

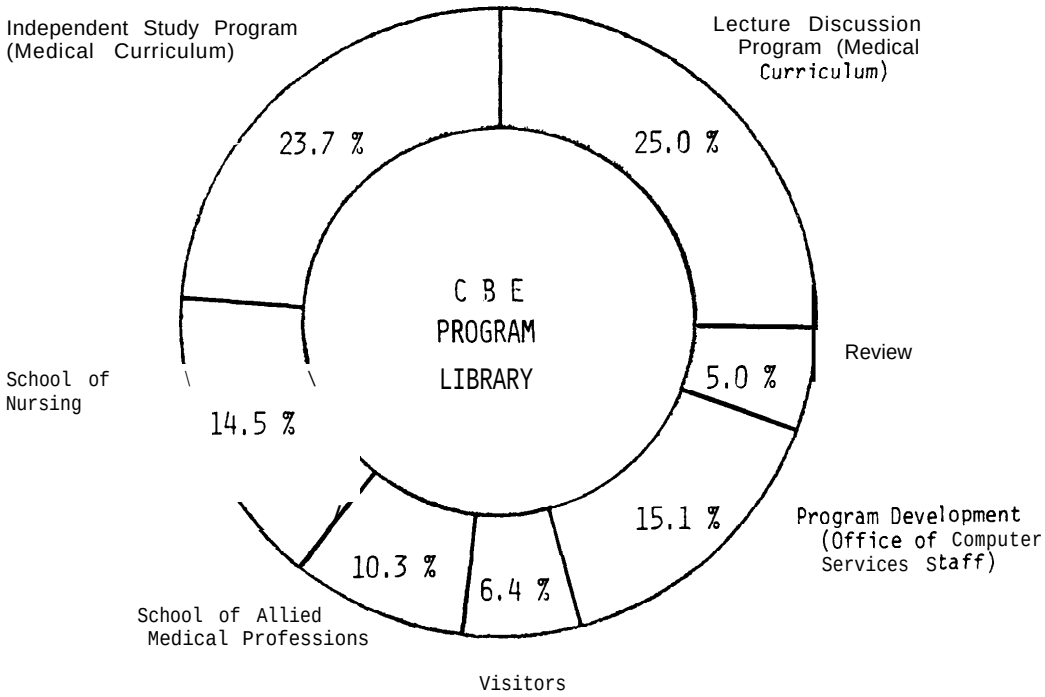
[a]This number represents the monthly average number of institutions throughout the country accessing OSU CBE materials
Each institution may have a number of terminals which are used for accessing the system
[b]January-June 1977
SOURCE Ohio State University College of Medicine, 1978.

Although early CBE efforts at Ohio State received considerable outside funding, current operational support comes primarily from college funds *(68* percent) and from income generated through National and State network use *(32* percent). Users of the Health Education Network pay $6 to $10 per connect hour depending on volume of use. Users in the CAIREN network pay approximately $650 per month for unlimited access through a single terminal. Average user dollar expenditures for CAIREN are shown in figure 15. All cost figures include expenditures for CBE courseware development.

The University of Illinois School of Basic Medical Sciences

The University of Illinois was one of the first institutions to use the programed logic for automatic teaching operations (PLATO) system for computer-based education in the health sciences. The PLATO system, developed at the University of Illinois Computer-Based Education Laboratory (Bitzer and Boudreaux, *1969),* is primarily committed to

Figure 14.–CBE Usage Profile for the College of Medicine (1977)



SOURCE The Ohio State University College of Medicine, 1978

Table 14.— Computer-Based Education Utilization Summary for the College of Medicine

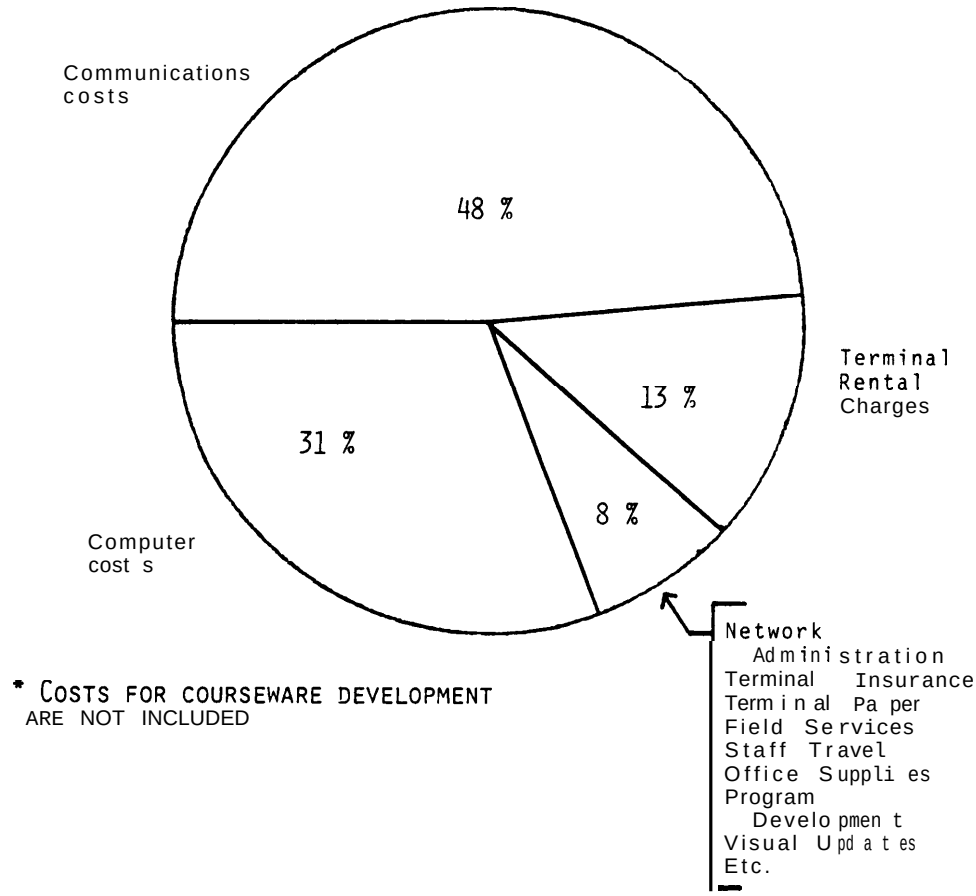
Year	Hours	Percent increase/decrease
1972	9,693	—
1973	16,884	+42.6
1974	19,159	+11.9
1975	17,140	–11.8
1976	21,711	+21.1
1977	20,737	– 4.7

SOURCE Ohio State University, 1978

research in CBE. However, it also is used to support accredited instruction in a variety of subjects during at least 80 hours of a typical week at the University (Hody and Avner, 1978). Currently some 950 terminals are linked to the system (Bloomfield et al., 1978). The unique graphic, audio, tactile, and other capabilitiesof the PLATO terminal distinguish it as one of the most advanced CBE terminals available (Sherwood and Stifle, 1975).

The University of Illinois' PLATO system and its several years of operational experience provided the requisite groundwork for the School of Basic Medical Sciences to develop a computer-based core curriculum. This effort began in 1973 with funding from both the U.S. Department of Health, Education, and Welfare and the State of Illinois. Lessons used in CBE provide both primary and supplementary instructional materials, drills, vocabulary builders, and simulations. Building upon the initial CASE work (Harless et al., 1973), simulated exercises now involve social counseling, differential diagno-

Figure 15.—Average User Dollar Expenditures*
Computer Assisted Instruction Regional Education Network (CAIREN)



SOURCE: The Ohio State University College of Medicine, 1978

sis, physician attitudes toward the dying patient, as well as traditional case studies of diseases (Bloomfield et al., 1978).

A computer-based diagnostic examination system, used in the undergraduate medical curriculum, allows students to evaluate themselves. Students are encouraged to take an exam via the PLATO terminal after they have completed each of 10 clinical problems. Each exam lasts about 2 1/2 hours, allows the student an opportunity to retry questions, and provides literature references for incorrect responses. Combining all types of CBE materials, there are about 150 modules of basic medical science materials.

In 1974, PLATO terminals were made available to a number of medical schools upon their agreement to author lessons and to make the materials available to their students. Illinois provided the terminals and computer time free; participants paid a share of the service costs and all of their communication costs. Seven institutions have taken advantage of this opportunity. These seven and Illinois have logged over 17,000 student instructional hours on 80 terminals, or over 4,000 to 5,000 hours per year of use. This level of use accounts for approximately 10 percent of the total University of Illinois PLATO system use (Bloomfield et al., 1978). The number of PLATO users is growing as more courseware is made available.

Massachusetts General Hospital

The Massachusetts General Hospital (MGH) Laboratory of Computer Science developed its first computer simulations approximately 10 years ago. The programs were developed to teach and test clinical problem-solving skills and serve as a supplement to traditional methods of medical education.

The MGH data base now contains simulations in approximately *30* subject areas; most of the topics are presented in a case-oriented format (see appendix I). Each case requires approximately 10 to 45 minutes to complete, depending on the program strategy, the format employed, and the pace preferred by the user. The user can select whatever content material is of particular interest and a time and location that are most convenient. Programs are updated frequently. User comments, analyzed daily by the MGH staff, are often the source of program revision.

MGH became the first host computer on the experimental Health Education Network in 1972. Since May 1975, the programs have continued to be available through a national communications network with MGH assuming administrative and financial responsibilities. Under contractual arrangements, user institutions are charged for program use on a monthly basis.

In the past 7 years, MGH has served *20,000* individuals in over 150 institutions throughout the United States and in several foreign countries with approximately 70,000 hours of computer-based medical education. Monthly usage has ranged from 20 to more than 1,500 hours. While institutions using the MGH materials vary in size and type, most user groups are medical schools or university medical centers (68 percent of total groups) and hospitals (16 percent).

Through local and hospital program use as well as the network activity, MGH provides access to its computer simulations for medical students, physicians, and other health professionals. In undergraduate medical education, some students use the programs as required or recommended course material; others use them on an ad hoc basis for independent study. Programs are used by individuals and by student or student/teacher groups to discuss alternate actions and likely outcomes at each point requiring user input. To enhance the learning experience, most of the simulations have HELP or CONSULTATION options to offer medical or program advice in addition to the feedback to a particular response.

In graduate medical education, practicing physicians use the simulations for private self-assessment, for continuing medical education, and for certification and recertification requirements. Acceleration in the growth of medical knowledge, diversity of training programs, and growing State and specialty society requirements for continuing medical education activity have contributed to the need for new sources of continuing education credit.

The Harvard Department of Continuing Education has approved many of the MGH programs for over 70 hours of Category I credit toward the Physician's Recognition Award of the American Medical Association (AMA). Also, CME approval has been received by two specialty groups: The American Academy of Family Physicians (AAFP) for elective credits and The American College of Emergency Physicians (ACEP) for Category I credit. Table 15 lists the program names and shows the maximum number of hours of continuing education credit for which each program can be used. Physicians using the MGH programs can register for credits on-line at the time of program use. At the end of the registration period, a certificate listing total hours earned is forwarded to

Table 15.—Massachusetts General Hospital: Computer-Assisted Continuing Medical Education Program (1979)

Program module	Maximum hours approved by: AMA[a]	AAFP[b]	ACEP[c]
Abdominal pain	5	5	5
Arterial blood gas	3	3	2
Cardiac arrhythmias	3	3	4
Cardiopulmonary resuscitation	10	10	6
Coma	10	10	14
Cough and fever (Pediatrics)	5	5	6
Digitalis usage	5	5	—
Diabetic ketoacidosis	—	—	3
Fluid and electrolyte management	2	2	2
Gastrointestinal bleeding	3	3	5
Hypertension diagnosis	5	5	—
Hypertensive emergencies	3	3	3
Hypertension treatment	10	10	—
Joint pain	5	5	5
Orthopaedic problems	3	3	1
Respiratory distress—newborn	3	3	—
Trauma	3	3	4

[a]American Medical Association
[b]American Academy of Family Physicians
[c]American College of Emergency Physicians.
SOURCE Health Education Network information Packet, 1979

the participating physician. With a computer terminal and a telephone call (usually local) to the network, a physician can have a personal, interactive method of education from home, office, or hospital without leaving his/herpractice to attend acourse orlecture.

The programs have proven to be quite popular with a large number of medicaI students and physicians. Users have expressed a very positive attitude to the computer teaching experience as a valuable supplement to other educational formats. This unique approach to medical education is judged as entertaining and productive. The continuing survivaI of the network with no outside funding also attests to the favorable appraisaI given the programs by thousands of users.

NETWORKS, CONSORTIA, AND OTHER DISSEMINATION MECHANISMS

Interinstitutional sharing of CBE resource materials is necessary if CBE is to continue to be used in the health sciences. The impetus for resource sharing is provided by a variety of factors. For example, the high developmental costs of CBE materials make sharing a necessity; no one institution can afford to develop all the courseware to meet its needs. The costs of maintaining hardware are also high. It is not cost-effective or even possible for faculty authors, who must ensure the ongoing relevance and accuracy of the materials, to perform maintenance functions or distribute lesson updates to each institution that uses them. Via networking, the most scarce resource, the author, is effectively shared, because all users are on-line and interact with the same copy of the CBE courseware.

Via “off-line” sharing, author resources also are shared, but updated and new courseware must be added continually to the computer at each user site. Hence, “off-line” sharing of CBE materials will depend on the availability of mechanisms to develop and provide access to modified versions of each program. “On-line” sharing in contrast, is subject to the costs of long distance communication. Another obstacle to sharing CBE is

the lack of cooperation among schools in developing and distributing learning resource materials.

In this section, programs that utilize the three mechanisms for sharing CBE materials are summarized: the Health Education Network, Inc., on-line use; the Computer-Assisted Testing Consortium (CATS), transfer of CBE programs off-line from one institution to another; and Milliken Communications Corporation (MCC), transfer of programs off-line to a single individual.

The Health Education Network

The Health Education Network, Inc., evolved from a federally supported and federally directed experimental network to a user-supported and user-directed operational network (Wooster, 1976). In 1972, the Lister Hill National Center for Biomedical Communications of the National Libary of Medicine established an experimental network to: 1) assess the technical feasibility of interinstitutional sharing of CBE materials through networking, and 2) determine whether CBE materials developed at one institution would be accepted and used by others. Both the technical feasibility of networking and user acceptance of sharing CBE materials were established in *1974*, after 18 months of network operation. Federal support continued until May of 1975. Currently, the Health Education Network enables institutions to share CBE materials at a fraction of the cost of developing and maintaining these materials individually.

The federally supported experimental network began as a result of a 1968 conference sponsored by the Council of Academic Societies of the Association of American Medical Colleges and the Lister Hill Center. Conference participants concluded that there was a need for a national network and that there were many services that might be provided. As a result, the Lister Hill Center convened a meeting in 1971 of potential hosts to discuss providing programs for networking. The center thought it could obtain programs from the hosts, put them on a central computer, and distribute them to users. Hosts were willing to share the programs, but they insisted that the programs reside on their own computers for continued courseware control and maintenance by the author team. Potential hosts disagreed with the center's demonstration plans. The center wanted to demonstrate programs to a wide group of users by employing a small number of programs; the hosts, on the other hand, wanted to work extensively with a small number of users. This issue was resolved by devising two classifications of users, trial and operational.

In June 1972, MGH became the first hospital to offer materials on the Network. Two months later, The OSU College of Medicine was officially connected to the Network, and in January 1973, the University of Illinois Medical Center was joined to the Network. Connection involved installation of a TYMNET minicomputer and development of software to interface with the host computers. MGH was an original test site for TYMNET node connection to Digital Equipment Corporation hardware, and OSU was an original test site for TYMNET node connection to IBM *360/370* series equipment. Given the "stat e-of-the-art," a period of some months was required to achieve smooth transmission of technical messages and to establish a stable and reliable network connection for users.

The University of Illinois Medical Center ceased to be a host on the Network in May 1974. The Lister Hill Center made the decision to transfer a portion of that data base, the CASE simulation materials, to the OSU College of Medicine.

Initially, the experimental network provided free service to institutions willing to support their own computer terminal(s) and connection to the nearest TYMNEI" network

node. The center did not anticipate the high user acceptance which was, in fact, so great that the center was forced to recover some of its costs from participating institutions. In February *1974,* user charges of $2.50 per connect hour were instituted. Network usage continued to outreach budget allocations. Therefore, a plan evolved both for gradual increases in user charges and for beginning the transition from a federally supported network experiment to a user-supported network.

Less than a year after the first user fee announcement, the Lister Hill Center increased the usage fee to $5.00 per connect hour. Still, the fee covered less than one-third of the total cost for Network operation. This circumstance is perceived as a major reason for the decision and subsequent announcement by the Lister Hill Center in January 1975, to withdraw support from the Network in May 1975. In May of 1975, the Lister Hill Center officially terminated its support of the Network. The next day the operational, user-supported Network began. By June 1976 the Network had become an incorporated, tax-exempt organization.

The Health Education Network is managed by a board of directors elected by the user communities of various hosts who coordinate their sharing under the Network umbrella. The Network is comprised of: 1) host institutions with well-developed health-related CBE materials on their own computers, 2) a communications carrier with a nationwide network, 3) institutions that wish to access and pay for available CBE courseware, and 4) a management structure to preserve and enhance the interinstitutional sharing (Tidball, 1978).

Currently, the Network's hosts are: the OSU College of Medicine, MGH's Laboratory of Computer Sciences, The University of Texas Health Sciences Center at Dallas, and Washington University (St. Louis) Department of Surgery, and Milliken Communications Corporation (as joint hosts). Through these hosts, the Health Education Network provides access to the largest library of health-related CBE materials in the world—over 600 interactive hours. The Network's CBE materials are comprised of the cumulative data bases of the several hosts.

Access to the library of programs is provided through TYMNET, a commercial telecommunications company that operates a nationwide network with approximately 165 connected sites. Using almost any computer terminal, the user need only to call the nearest connected city on the Network to access any Network host.

To date, over *150* institutions have used the Network. The largest groups of users have been medical schools *(65* percent) and teaching hospitals (10 to 15 percent); other categories of users include professional societies, group practices, allied health schools, Federal agencies, industry, and individuals. Some *60* institutions are now members of the Network. Cumulatively, the Network has provided over 250,000 interactive user sessions, with on-line usage ranging from 600 to 2,000 hours per month. Composite, annual use of the Network is presented in table 16.

Member institutions use the Network for a variety of purposes. Many use the Network primarily for demonstrations, faculty education, and as an optional learning resource for students. Several institutions have integrated the Network's CBE materials into their teaching programs; some have required CBE courses that are offered by the Network, especially anatomy and physiology. The University of Washington modified the OSU independent study tutorial programs to meet the needs of their own independent study program. Before a local system was available, the medical students in Seattle used CBE programs based in Columbus, Ohio, to pursue their medical studies.

Table 16.—Health Education Network (annual hours of use)*

Year	Hours
1972	1,340
1973	18,140
1974	19,390
1975	15,600
1976	14,800
1977	12,820
1978	12,940

"Source of CBE materials only from Ohio State Unversity and Massachusetts General Hospital

The Network has supported computer-based continuing education activities by such groups as the Connecticut and Ohio Academies of Family Physicians, and the American Academy of Orthopedic Surgeons. Without the Network, many such activities could not have been undertaken.

The current cost to the user of the Health Education Network ranges from $4 to $10 per connect hour depending on the time of day (prime time v. nonprime time) and the level of user commitment. The higher the commitment in usage hours, the lower the unit cost. The Network supports a wide variety of terminals that can be purchased for less than $2,000 or rented for $50 per month. The user institutions provide their own computer terminals and phone connections to the nearest Network node. Hourly user fees include local host computer costs, costs for personnel to support and maintain the hardware and software systems, costs for personnel to provide support to users, and communication costs. Charges for development and evaluation of CBE materials and for assisting users in curricular incorporation of the CBE materials are not included. These costs are generally assumed by the hosts, which have developed the CBE materials for their own use.

The Network has stimulated the development of educational computing in the health professions and increased awareness of the potential of CBE. Faculty, student, and staff users have had an opportunity to use a new learning resource without a large initial investment in hardware, software, or personnel. They have had access to recognized materials and to the work of accomplished CBE authors. FacuIty aIso have had the opportunity to develop new lessons or alter existing lessons from their own terminals. Finally, they have had access to computer and educational consultants at the host sites.

The quality of CBE materials has improved as a result of national exposure. Widespread peer review, although still an emergent phenomenon, has accelerated review and refinement of programs. Remote authoring has further refined course development and added new materials to the CBE library. Reliable, multi-institutional access to, and use of, lessons has fostered developments in CBE materials analogous to publication in the print media.

Via the Network, the hosts have a relatively trouble-free mechanism for sharing their CBE materials with others. Sharing materials has forced other changes that are of long-term benefit to hosts and users, including: the development of simplified procedures for user access; the implementation of standards for courseware documentation; improvements in remote authoring; and the refinement of user services to address the problems of consultations on the use of CBE courseware. In addition, reporting systems and program development procedures were generalized, extensive management reporting systems were installed, and methods of billing and contracts management were implemented.

The Computer-Assisted Teaching Systems Consortium

The Computer-Assisted Teaching Systems (CATS) Consortium is a CBE sharing mechanism whereby participating medical schools cooperate in the development of new approaches to medical education, exchange educational and CBE materials, and generally encourage the development of innovative teaching in pharmacology (Doull and Walaszek, 1978). The system primarily uses computer assisted and managed testing (CAT); however, the system also uses some computer-assisted instruction (CAI).

The Health Education Network, Inc. shares materials "on-line" via network link of the user to the host computer. CATS, in contrast, shares materials "off-line" by sending computer tapes, documentation, and other materials to the user for operation on his/her own computer. This choice of sharing mode was consciously planned to enable users to control the program's uses and modifications and to minimize user costs by avoiding expensive communication links. Although developed on IBM computers, the system may be used on several types of large computers and on minicomputers.

Similar computerized test-item banks exist in several basic science areas, most notably pathology (Group for Research in Pathology Education, 1974) and physiology (Dennis, 1978). The pathology materials are maintained in Iowa and shared through a consortium similar to CATS. The physiology materials are maintained at OSU and are shared through the Health Education Network and CAIREN,

In *1970,* the Department of Pharmacology began developing a system that would both teach pharmacology more effectively to medical and nursing students and attempt to meet the needs of medical technicians, hearing and speech therapists, graduate students, pharmacists, house staff, and other health professional groups. Pharmacology course material was subdivided into a number of modules or units, and CAI and computer-managed instruction /computer-assisted testing (CMI/CAT) materials were developed to help assess student competence in each of these modules or units.

CATS was used on a pilot basis in 1971 and 1972 to teach pharmacology to medical students and was fully implemented and extended to other teaching areas in pharmacology in 1973. The CATS Consortium was formed in 1974 and includes over *50* American and 12 European medical schools. They all use the CATS CMI/CAT materials developed at the University of Kansas Medical Center's Department of Pharmacology. A much smaller number use the CAI materials.

The CMI/CAT portion of CATS contains over 25,000 test items, along with software, to create and maintain new questions, to generate tests from the test-item bank, and to grade and post scores from the exams. Only objective type, versus open-ended or essay type, questions are included in the CMI/CAT item bank. The questions come from recent exams given by the Kansas pharmacology faculty, various Consortium members, and other pharmacologic colleagues of the Kansas faculty. New questions are screened for appropriateness and acceptability of question-type format. Each question is classified and tagged so that it can be automatically retrieved by content and difficulty when a test is generated. Questions are reviewed for currency and correctness when they are selected from the file for inclusion in the exams, rather than when they are added to the file.

Faculty responsible for teaching each unit in pharmacology decide how many exams they wish to prepare and how many questions from each category they wish to include in their exams. The faculty can personally select test items from a large set produced by the computer, or they can use statistical information or a random number generator to produce a test for their review.

At Kansas, exams containing 100 questions in each of the 5 units of the pharmacology course are offered weekly throughout the 20-week teaching period. Each student who registers for the independent study program is given a packet of prepunched cards containing his/her name, number, mail box number, and course number and section. Whenever a student wishes to take an exam, he/she submits one of the cards, and an optical scanning answer sheet with individual information is generated. The sheets are automatically scored and reports for the faculty and the department are prepared. Item analysis information is added to the question so that cumulative data can be kept on the difficulty and use, for example, of each question.

The CAI portion of CATS serves primarily as an enrichment or adjunct to the medical student pharmacology course. Although only a few optional CAI programs were available in 1972, 98 percent of the students in a pilot program used all of the programs, and virtually all were in favor of expanding this approach. A significant increase was demonstrated in student performance in both of the pharmacology units in which CAI material was available (Norton et al., 1972). Currently over 120 simulations and tutorials are used, for an average of 20 hours by each of the 160 medical students at Kansas. These CAI programs are available to CATS Consortium members, although most use only the CMI/CAT portion of CATS. This is due in part to the difficulties in translating the CAI programs to other computer languages and to the costs of CAI operation as compared to CMI/CAT operation (Doull and Walaszek, 1978).

Consortium growth indicates that faculty are willing to use materials developed by others if they have some editorial control over the materials. Also, the availability of a body of materials that covers a defined subject area facilitates incorporation of the materials into ongoing educational programs rather than into optional, adjunct programs. Another important aspect of the CATS Consortium is the membership requirements; each school must contribute questions to the item bank and its data must be made available to others for revision of questions and for peer review purposes. This facilitates sharing because each school considers itself an active, rather than a passive, participant.

Milliken Communications Corporation

Milliken Communications Corporation (MCC), a for-profit publisher of CBE materials, is a wholly owned subsidiary of Milliken Publishing Company formed specifically to develop and market CBE continuing education materials to physicians. Its courseware is entirely oriented to continuing education provided through the use of microprocessors and the home computing market.

In 1975 the Department of Surgery, Washington University School of Medicine, began the experimental development of a CBE system to provide students with individualized instruction in general surgery and to determine the feasibility of CAI as a means of providing postgraduate continuing medical education (Halverson and Ballinger, 1978). The work was initially supported by the Institute of Medical Education and Research, St. Louis, Me., and by Milliken. CBE courseware was authored by experts from across the country, and the Department of Surgery coordinated the effort. A series of computer programs called “drivers” were prepared so that authors could write and edit CBE seminars without learning computer programing. The standard MUMPS language and PDP computers were used for the development of the CBE programs (Bowie and Barnett, 1976).

The seminars were initially used by medical students as a supplement to the usual third-year general surgery curriculum. Although use of the CBE materials was not com-

pulsory, about two-thirds of the students took advantage of these materials. Eighty-five percent of the 59 students felt the experience was beneficial and wanted more opportunities to take CBE seminars (Halverson and Ballinger, 1978).

As an outgrowth of the success of the Department of Surgery's efforts and with its help, Milliken Publishing Company formed MCC to adapt the undergraduate seminars to continuing education courses. Milliken, in conjunction with Washington University, is now developing continuing education series in internal medicine, primary care, and psychiatry. Experts author the materials, and MCC provides programing and computer support. An editorial board consisting of Washington University and MCC personnel review all materials. MCC pays a varying honorarium, but no royalty, to its authors. To date approximately 70 authors from 30 medical schools have participated (Milliken Communications Corporation, *1979).*

Milliken's CBE seminars are designed to simulate a conversation between the physician and the author; the mode is primarily tutorial. The computer presents a concept or basic information and asks the physician a question that requires recall, inference, or judgment. The physician responds by typing in his/her answer; the computer responds using the preprogrammed responses provided by the author. Table 17 shows the seminars currently being marketed by MCC. Over 50 interactive hours are now available, with more in development. The 'number of Category 1 Continuing Education Credit hours which can be earned is noted following each seminar title. To receive credit, the physician places the computer-generated completion code on a completion card and returns the card to Milliken.

Table 17.—Continuing Education Seminars Currently Marketed by Milliken Communications Corporation

Surgery	AMA category 1 credit hours
Surgical infection	2.0
Diagnosis and treatment of abdominal injuries	1.5
Immunology for surgeons	1.5
● Surgical treatment of peptic ulcer disease	1.5
● Gastrointestinal inflammatory disease (Crohn's disease)-1	1.5
Acute and chronic pancreatitis	1.5
Surgical parathyroid disease	1.0
Gastroesophageal reflux	1.5
● Clinical management of advanced breast disease	1.5
● Multiple endocrine neoplasis	1.5
Malignant melanoma	1.5
Peripheral arterial disease-1	1.5
Peripheral arterial disease-n	1.5
● Colorectal polyposis	1.0
Cutaneous thermal burns	1.5
Surgical nutrition	1.5
Colorectal cancer	1.5
● Gastrointestinal bleeding	1.5
● Gastrointestinal inflammatory disease-n	1.5
● Shock	1.5
● Cancer of the thyroid	1.5
● Trauma	1.5
● Portal hypertension	1.0
Extrahepatic biliary surgery	1.5
● Thrombosis, thrombolysis and thrombophlebitis	1.5

Internal medicine	AMA category 1 credit hours
● Management of cardiac arrhythmias-1	1.5
● Management of cardiac arrhythmias-n	1.5
● Management of cardiac arrhythmias-ill	1.0
● Athletic injuries (jogging and tennis)	1.5
● Clinical approach to patients with chronic obstructive lung disease	1.5
● Asthma	1.5
● Chronic renal failure	1.5
● Gonorrhea	1.5
● Hodgkin's disease	1.5
● Thyroid dysfunction	1.5
*Understanding nutrition	1.5
● Evaluation of cardiac sounds	1.5

"Also qualifies for primary care.
SOURCE: Milliken Communications Corporation, St. Louis, Mo,, 1979,

Seminars are programed and stored on courseware diskettes that provide approximately 45 minutes of interaction each and can be used hundreds of times. The user can start, stop, exit, and reenter the seminar at will. To use the CBE seminars, the physician must purchase or lease an APPLE microprocessor (the same model available in hobby or home computing stores), and the diskettes which contain the CBE materials. MCC seminars are also available for demonstration through the Health Education Network, but, thus far, usage has been limited to less than *200* hours (Milliken Communications Corporation, 1979).

MCC both sells and leases all materials and equipment. The purchase price of the total system ranges from *$2,525* to *$2,850,* depending on the number of diskettes purchased; the lease price ranges from *$200* to *$300* per month, depending on the length of the lease; and individual diskettes cost $2o to $22, depending on the number purchased.

APPENDIX