Strategies for Integrating Computer-based Activities into Your Educational Environment: A Practical Guide

Abstract Strategies for implementing instructional technology are based on recent experiences at the University of Michigan Medical Center. The issues covered include 1) addressing facilities, hardware, and staffing needs, 2) determining learners' skill requirements and appropriate training activities, and 3) selecting and customizing educational software. Many examples are provided, and nine key points for success are emphasized.

The history of modern education is littered with the trash of technology left behind by unrealistic purchases, naive users, and vendor representatives working on a quota system.

—E. Polley (1977)

It has been 11 years since publication of the 1984 report of the Project Panel on the General Professional Education of the Physician and three years since publication of “Educatin Medical Students: Assessing Change in Medical Education—The Road to Implementation (ACME-TRI Report).” The controversy over computers in medical education seems to have moved from “why” to “how.” As many schools revise their curricula to reduce the number of hours students spend in lectures and to increase the amount of time spent in small-group or independent problem-solving activities, they find that judiciously selected computer-aided instructional materials can serve as adjuncts to more traditional learning activities. Students must emerge from their undergraduate educational programs equipped to deal with the influx of information technology in the everyday practice of medicine as we enter the 21st century; yet 39.4% of the 12,096 medical school graduates responding to the 1992 Association of American Medical Colleges’ Graduate Questionnaire felt that the amount of time spent on use of computers was inadequate.

Constraints beyond limitations of money and space hinder the introduction of computing into medical school; these include the lack of curricular time for the introduction of a new course on computing and information technology, the rapid changes in computer technology, and a lack of appropriate educational software. Recently published reports indicate that more institutions mandate “medical informatics” and computer skills training for their undergraduate students. Target proficiencies in areas of information technology include skills ranging from electronic mail to bibliographic referencing software. Many institutions have formal requirements to ensure that students graduate from medical school with a certain degree of “computer literacy.” Koschmann’s recent reflections on the importance of learning about, through, and with computers are especially relevant to the introduction of computers and information technology into medical school curricula.

Strategies and Recommendations

This paper provides examples of the strategies that have been successful at the University of Michigan over many years. These strategies represent a practical
guide to computer-aided instruction (CAI) in that they are designed to overcome, or at least minimize, the barriers to successful integration of information technology into the curriculum. Nine key points for success are emphasized: 1) encourage students to use computers on a regular basis by locating them conveniently, 2) link training with required curricular activities, 3) use more advanced students as role models to assist in teaching, 4) focus on known content areas in which students need help, 5) use off-the-shelf software whenever possible, 6) collaborate with content specialists to customize purchased software, 7) rely on outside sources to help identify existing software programs, 8) be willing to share curricula and software with colleagues at other institutions, and 9) learn the basics of computing, but depend on experts for more complex information-technology support.

Facilities, Hardware, and Staffing

If more than minimal use of computers is expected in fulfilling course requirements, computing resources must be placed in comfortable and central locations. At the University of Michigan Learning Resource Center (LRC), we have two major computing facilities located in close proximity to the preclinical students’ lecture halls, laboratories, and the medical library. The LRC Multimedia Instructional Laboratory (the “cluster”) is located on the third floor of the Taubman Medical Library and offers access to 60 computers as well as more traditional audiovisual equipment and study materials. The CAI Lab, a 22-workstation facility that is geared toward computer usage by small groups of students and can accommodate as many as 88 students, or approximately half a class at one time, is located in an adjacent building. In addition, five smaller satellite educational computing laboratories with three to five computers each are located on each floor of the main hospital and are used by students on the wards. All sites are wired to the medical center’s ethernet backbone, allowing access to internal file servers as well as to external information sources via the Internet, using Transmission Control Protocol/Internet Protocol (TCP/IP).

During the past year, five lecture halls in the medical school have been renovated and transformed into electronic classrooms to provide instructors with state-of-the-art audio and video projection capabilities. Computers are wired into the projection systems to provide access to the University of Michigan Medical Center’s ethernet backbone, which allows instructors to connect to their local departmental file servers or to the World Wide Web (WWW) for demonstration purposes. Ford Amphitheater, the largest hospital auditorium, has undergone similar renovation, including a newly installed fiberlink allowing connectivity for two-way videoconferencing between this facility and a neighboring Veterans Administration Hospital. Classroom-services staff meet with individual instructors to provide orientation sessions to the equipment, and do-it-yourself instructions are posted by control panels in each lecture hall.

Selected courseware is mounted on a Novell Netware-based file server, physically located near the LRC. We attempt to purchase network versions of software whenever possible, because of programming and site-licensing constraints. Educational computing at the University of Michigan is primarily Macintosh-based; therefore, only 5 of the 60 machines in the computer cluster are DOS/Windows systems. Despite the growing trend toward cross-platform software development, several programs are still available only on a single platform. Consequently, five Power Macintosh computers can also be used to run DOS/Windows programs in emulation mode when additional platforms are necessary. The LRC is supported in part by the university’s information technology division (ITD), which deploys 40 of the 60 computers in the LRC and contributes a portion of the salaries of the part-time employees; additional funds for staffing, supplies, and additional equipment are provided by the medical school dean’s office. A 5-year replacement cycle is used for the numerous computers at our sites. Older computers are often suitable for word processing, e-mail, conferencing, and literature searches, even though they do not have sufficient processor speed or RAM required for the newest video-intensive multimedia programs. One must maintain a reasonable perspective on the real computing activities that must take place in an environment. Providers must avoid the “innovation frenzy” described by Friedman,2 which can cause paralysis in trying to keep up with the technologic changes inherent in the computer industry. Faculty members are advised to consider hardware limitations when considering the implementation or development of CAI programs for their courses. Activities are structured to avoid long waiting lists for particular groups of computers.

The LRC computer cluster remains open until midnight on weekdays, and the check-in desk is staffed by knowledgeable part-time student employees who can assist students, faculty, or staff with basic computing questions. We tend to hire students from the engineering and information/library science programs, but we consider all applicants who possess sufficient knowledge to assist patrons with their questions on e-mail, conferencing, Internet connectivity,
and the basic productivity-software packages supported by the university. The students are paid approximately 35% over the current minimum wage in recognition of the skill set required. We attempt to keep salaries at a level comparable to those of other, similar positions within the university. One student is sufficient to staff the desk during normal daytime hours, but when no permanent LRC staff members are present in the evenings and on weekends, we prefer to have two students working at all times; thus, the total staffing time is approximately 110 hours per week, or about 2.7 full-time equivalents. Staffing for the CAI Lab is based on the first-year students’ lecture schedule, and the CAI Lab is typically open during daytime hours, when the students are not required to be in class, approximately 20 hours per week, or 0.5 of the full-time equivalent.

Professional staff from the LRC’s Medical Instructional Computing (MedIC) group are available during normal working hours, and at other times by appointment, for consultation on selection and introduction of computer-based activities for the curriculum, or to aid faculty, staff, or students with more complex computing problems. The ITD also maintains university-wide telephonic and electronic “help lines.” Patrons are encouraged to seek such assistance when their questions are beyond the scope of the LRC staff. A full-time supervisor of public computing facilities trains and schedules part-time employees and oversees the day-to-day mechanics of the sites. In addition, the MedIC staff includes two full-time computer consultants with training in film, video, programming, and instructional design. A part-time medical illustrator/graphic designer is also available. Staff members from our classroom-services unit who specialize in computer systems and audiovisual systems design, are also available for projection and audio assistance in training workshops held during normal working hours.

We serve as the administrative staff at the LRC and are actively involved with other faculty members at the medical school in teaching and research activities. Planning the introduction of computer-based exercises provides opportunities to interact with other faculty members as “colleagues.” The LRC director is a faculty member who teaches in both the preclinical and clinical segments of the curriculum and also serves on several curricular committees. The LRC manager, a biologist with extensive experience in computer programming, has training as a medical librarian. Both are actively involved in conducting workshops, and they each teach a fourth-year student elective course.

**Determination of Skill Requirements and Appropriate Training**

The University of Michigan curriculum requires facility in basic skills that include using electronic mail and computer conferencing, browsing the WWW, being familiar with computer decision support systems, accessing literature databases such as MEDLINE, and understanding the medical center’s clinical information systems. Opportunities also exist for senior students to select elective courses such as “Computers in Medical Education” and “Critical Appraisal of the Medical Literature and Application to Patient Care.”

Incoming freshmen are given a 3-hour introduction to basic skills and systems during a training session on electronic information management, cosponsored by MedIC and professional staff from the Taubman Medical Library. MedIC staff members assist students in changing their system-generated passwords, signing on to the University X.500 electronic address directory system to update their entries, and providing a short, hands-on introduction to electronic mail using PINE (developed by the University of Washington), a client/server-based Interactive Mail Access Protocol service provided by the university’s information technology division. E-mail may be accessed via Macintosh computers, PCs, or UNIX-based computers. The University of Michigan MEDNET Conference¹³ (Conference-U, Advertel, Inc., Ann Arbor, MI) is demonstrated, and students learn how to index items, browse the various discussions, and send messages to other participants. Both e-mail and conferencing are used by course instructors to present patient care problems for discussion, communicate with students individually, and to post changes in lecture schedules and seminars.

The library staff instructs students in the use of MIRLYN, the University of Michigan online library catalog and MEDLINE, currently accessed via a site license to PaperChase (Beth Israel Hospital, Boston, MA). Students are required to conduct MEDLINE searches for short papers in the sequence “Introduction to the Patient” in their first year and throughout the following 3 years.¹⁴¹⁵ Finally, the WWW is demonstrated using the Netscape Navigator browser (Netscape Communication Corporation, Mountain View, CA), and students learn how to access a variety of campus information sources and a variety of worldwide medical-information resource sites. We at the University of Michigan agree with Lundberg’s recent assertion that a surge in usage will occur in physician access to online medical information, and we want our students to be prepared accordingly.
Many medical school offices and departments use their Web pages to broadcast scheduling changes, fellowship deadlines, and other important information to students.

Students leave the workshop with detailed instructional handouts that can be used as reminders after the session and with instructions on how to configure their personal computing equipment for dial-in access to the various computing systems of the university. MedIC staff members are available on a walk-in basis or by appointment during the day at the LRC for assistance with these systems. In addition, shorter refresher sessions for MEDLINE, MEDNET, and the WWW are provided at later points in the curriculum when intensive usage is required.

Two-hour workshops are given in the middle of the second year to introduce students to ILIAD (Applied Medical Informatics, Inc.), a decision support system that is used in both simulation and consultation modes. Students are required to complete simple patient simulations during their second year and move on to more complicated and realistic simulations during their third-year clerkship in internal medicine. Finally, a series of three 2-hour sessions introduce students to the various clinical information systems (e.g., hospital information system, RADNET, PATHNET) at the end of their second year, immediately before they begin their clinical training.

We always have at least one physician on site during the presentation of clinical systems or exercises, and the MedIC staff also hires senior students to assist the freshmen and sophomore students in these sessions. We have found that the upper-level students usually have sufficient clinical knowledge to answer most of the questions posed by the less-advanced students, and can enthusiastically convey to them the utility of these systems.

**Selection and Customization of Software**

The MedIC staff members work with faculty members to identify appropriate opportunities for computer-assisted learning, to integrate computer-based exercises or CAI into their courses, and to help develop customized software for specific learning objectives if suitable programs cannot be located from outside sources. Faculty members often contact the LRC with queries such as “Can you locate a good program I can use at the beginning of the second-year neuroscience sequence for self-study and review of CNS anatomy?” Sometimes LRC staff members discover programs or resources that they feel will be of interest to staff or students, and contact appropriate faculty members to demonstrate these programs. Such “environmental scanning” or “net surfing” has identified software resources and WWW sites that have eventually been integrated into several courses.

Students are entering the institution with greater experience with information technology and exposure to sophisticated CAI materials, and are not tolerant of poorly designed, visually uninteresting programs. For a program to be offered in the LRC, it must be reviewed by both a computer consultant/instructional designer and a content expert. Many programs fail LRC review and are rejected for use because of poor interface design or incompatibility with our network or operating systems. Once it is determined that the software will operate in the facilities, it is reviewed by instructors for content. Many programs are rejected because of poor content, mediocre pedagogic design or inconsistency with course or instructor objectives. If a program is accepted, the MedIC staff determines how many copies of the program are needed for the activity envisioned by the instructor and makes a recommendation for purchase of multiple copies, or in some cases, a site license. Depending on the nature of the exercise and the amount of time needed to complete the assignment, anywhere from 10 to 20 copies of a program may be recommended for a class of approximately 170 students. In cases in which no network version of a program is available, students are assigned to particular computers for the duration of an exercise. Managing this situation is often problematic, because students become frustrated when they have to stand in line for “their” computer while other computers sit idle. If multiple copies rather than a site license of a program are purchased, the software can be “keyed” with a program like Keyserver (Gassafes, Inc.), allowing the copies to be deployed on several machines until all of the software “keys” are checked out. Such programs alleviate the problem of tying up machines when they are dedicated for a particular program.

Unlike other learning resource centers, which may be part of a library system and thus have acquisitions budgets and collection policies, the University of Michigan LRC is part of the dean’s office and rarely purchases software that is not directly integrated into the curriculum and paid for from course budgets. This practice ensures that programs do not languish on the shelf (or the hard drive). Occasional cost-sharing agreements are made between the LRC and various course directors for the purchase of costly programs. Often the LRC purchases the first few copies of programs with the expectation that additional copies will
be purchased by faculty once the program's utility is validated by student use and evaluation.

The programs that are voluntarily used by students—hence, the most popular—are those that allow them to practice their test-taking skills before examinations (such as QuizCards programs for reviewing gross anatomy and embryology) or that allow them to proceed at their own pace in working out problems or performing workup on patients with clinical problems, such as patient simulations developed locally in IILAD. Problem-based multimedia programs such as CARDLAX, developed at the LRC, are also very popular; they provide students with an opportunity to review skills in basic cardiology in the context of solving diagnostic challenges. Pure text-based programs are often rejected by students, particularly if they present no advantage over print materials that cover the same material.

Numerous possibilities, including case-authoring shells or customizable programs, are currently available for developing good simulations of patient cases, using data supplied by local faculty members if no pre-authored cases are found to be suitable. At the University of Michigan, more than 50 patient simulations in a variety of internal medicine areas have been created in IILAD by one of us (JGM) in consultation with clinical faculty for second- and third-year students. For example, "classic" gastrointestinal case presentations for second-year students incorporate instructor-provided images of manometry tracings, x-ray films, and biopsies, which are digitized and incorporated into cases to add realism to the students' experience in performing workups on patients in preparation for small-group discussions with clinical faculty. During the third-year medicine clerkship, students are required to complete an additional 12 simulations, which provide them opportunities to perform workups on patients who have pulmonary and cardiovascular chief complaints that are common in primary care. Students find these experiences valuable and enjoyable and often request additional cases.

Whenever possible, faculty are advised and assisted to look for off-the-shelf applications to meet their instructional needs. Although simple programs may be developed relatively inexpensively using tools such as HyperCard or Toolbook, the investment required for specialized software to build complex applications, to edit video and sound, or to create three-dimensional artwork can exceed several thousand dollars. Most instructors do not have experience in designing software and are unaware of the number of hours of "content expertise" it may take to create a quality program. Although the cost of licensing software for use by more than 150 medical students may seem expensive, the development of sophisticated programs can be excessive after hardware, software, and staff time are considered. The faculty members of the department of anatomy and cell biology have worked for several years with MedIC staff to create a multimedia program for teaching and reviewing gross anatomy, histology, and embryology. When a need for such software was realized in 1987, no comparable programs were available commercially, and the decision was made to create such a program locally. We have estimated the cost of developing our ATLAS-plus program at well over $100,000.

Although software that meets specific instructional needs can be difficult to locate, some good catalogs provide unbiased information about health sciences software, such as Software for Health Sciences Education: A Resource Catalog (6th edition; Learning Resource Center, University of Michigan Medical Center) and 1995 Healthcare CAI Directory (Stewart Publishing, Alexandria, VA). However, reviews of programs that describe individuals' or institutions' experiences with programs in situ are more difficult to find. Despite the attempts of groups such as the American Medical Informatics Association's Education Working Group to create databases of such reviews, published reviews are still difficult to find, and word of mouth may often be one's only recourse. We have had success in contacting colleagues at other institutions to discuss their experiences with a variety of programs and educational activities. The California Consortium in Informatics in Medical Educational Development (CC-IMED) has published the book Medical Educational Software: Programs Successfully Used in California Medical Schools (1995). In addition, software distributors often provide potential purchasers with names of users of their programs. To overcome the obstacles of software development and implementation, many institutions have banded together to share resources in regional or national consortia, such as the National Educational Medical School Consortium (NEMSC) or the CC-IMED. When weighing the information received from colleagues about their experiences with programs, one must determine the circumstances under which the software was deployed. In the end, however, there is no substitute for in-house demonstrations or testing of software.

Technical Assistance

Directors or managers of learning resource centers must understand computer technology but need not be experts. Staging successful computer-based activities requires the availability of experienced informa-
tion-technology personnel for assistance. As a first step, most instructional programs can be run from CD-ROMs, or easily installed on the hard drive of individual computers. More complex applications, such as electronic mail and computer conferencing, require that the computer, or computers, be able to communicate with other equipment via modem or network. An understanding of basic computer concepts and the ability to decode jargon are essential. The authors highly recommend the following resources: *The Computer Glossary* by Alan Freedman (1995; New York: AMACOM: The Computer Language Company, ISBN 0-8144-0268-2; also available in electronic version), *Computers in Medical Practice: Managing Patients, Information and Communication* by Jerome Osheroff (1995; Philadelphia: American College of Physicians, ISBN 0-943126-33-9), and the new BMJ series "ABC of Medical Computing," edited by Nicholas Lee and Andrew Hilman (BMJ 1995; 310(6995):1650–1752 and subsequent issues), for a quick and palatable introduction to computing and challenges in medical information technology.

**Conclusion**

Strategies for implementing instructional technology based on recent experiences at the University of Michigan Medical Center can serve useful purposes at other sites. The issues covered include 1) addressing hardware, facilities, and staffing needs, 2) determining learners’ skill requirements and appropriate training activities, and 3) selecting and customizing software.

Whenever new technology is introduced, it is always wise to start slowly so that small successes are demonstrated as one moves forward. One should begin with small projects when appropriate, pilot them with small groups of students, and fine-tune activities before leaping forward. Technologic solutions should be used judiciously to meet instructional needs. Results should be evaluated and then shared with colleagues at other institutions. Success breeds success. This process enables the standards for teaching excellence to rise and promotes the use of increasingly sophisticated instructional technology.

**References**