A number of reports in the past decade have concluded that the medical education system must be reformed. These reports often call for the incorporation of new technologies into the educational process. One technology that has found its way into the medical educational environment is the personal computer. This essay critically examines the introduction of the personal computer into medical education, focusing on computer-based learning (CBL). The author concludes that evidence demonstrating the effectiveness of CBL is weak, and evidence supporting the notion that CBL enhances learning (compared with traditional methods) is weaker still. The author also argues that the decision to use CBL in the place of face-to-face traditional instruction has important negative implications for participants in medical education and may undermine the important role of patients in the education of doctors.

Key Words: Computer-based learning, medical education, doctor-patient communication

INTRODUCTION

To study the phenomenon of disease without books is to sail an uncharted sea, while to study books without patients is not to go to sea at all.

—Sir William Osler (1945)

A recent monograph from the Institute of Medicine [1], Health Professions Education: A Bridge to Quality, declared that “education for the health professions is in need of a major overhaul.” This statement was prompted by a pair of reports that demonstrated that the American health care system often unnecessarily harms patients and consistently fails to deliver its potential benefits [2,3]. The authors of Health Professions Education described their monograph as an initial blueprint for the transformation of the health professions education that must occur if the health status, functionality, and satisfaction of the US population are to be enhanced.

Calls for reform in medical education are nothing new. Over the past 30 years, a number of reports have urged reform within medical schools and teaching hospitals [4-6]. In the most recent American Association of Medical Colleges (AAMC) [5] report, Educating Doctors to Provide High Quality Medical Care: A Vision for Medical Education in the United States, the properties of an ideal medical education system are described. The report outlines a number of educational objectives and states that “the system will . . . employ educational strategies of demonstrated effectiveness and employ educational technologies that enhance learning.”

The advances in information technology that have made the personal computer a pervasive influence in everyday life have also changed the practice of medical education at all levels. A recent review in The Lancet stated that “within less than two student generations, communication and information technology has been repositioned as an integral component of the medical school environment” [7]. In another paper, Kerfoot et al [8] stated that “a critical question for practitioners of medical education is how best to integrate emerging technologies into medical students education.” It is my opinion that the question needs to be modified in an important way. In an era when there is widespread acknowledgment that physician-patient communication is poor [9], responsible educators should want to know how best to integrate emerging technologies into medical students’ education without losing the elements of medical education that benefit from direct learner-to-teacher or learner-to-patient communication and interaction.

Integrating new technology into medical education has been recommended for decades. More than 25 years ago, Daniel Tosteson, MD [10], dean of Harvard Medical School, proposed that the use of “information-processing devices” be developed as a core component of the medical school curriculum. In 1993, the AAMC’s [4] report, Assessing Change in Medical Education: The Road
to Implementation, suggested that medical students “must be given a strong grounding in the use of computer technology to manage information, support patient care decisions, select treatments, and develop their abilities as life-long learners.” In the late 1990s, some medical schools began to provide personal computers to incoming students, and in many medical schools today, access to a personal computer is a requirement.

The personal computer has been used for a variety of purposes, including acting as an information acquisition device (Medline online searches), a surrogate patient (patient simulations, virtual reality), and a surrogate teacher in the form of computer-assisted instruction or computer-based learning (CBL). For the purposes of this paper, CBL is considered to be instruction that is dependent on the use of a personal computer, without guidance or teaching from a teacher or facilitator. Other terms commonly used in the peer-reviewed literature include computer-assisted instruction and computer-assisted learning. The purpose of this essay is to critically examine the use of CBL in undergraduate and graduate medical education. In the process, 2 questions are asked. First, what is the evidence that CBL meets the standards of “effectiveness and enhancement” outlined in the ideal medical education system described in the recent AAMC [5] report? Second, are there significant unintended consequences of CBL on the stakeholders in medical education?

CBL: WHAT IS THE EVIDENCE FOR EFFECTIVENESS OR ENHANCEMENT?

The effectiveness of CBL is explored initially from the perspective of evidence-based medicine. Within the framework of evidence-based medicine, the best evidence on the effectiveness of an intervention comes from systematic reviews of multiple controlled, randomized trials in which experimental interventions are compared with control interventions (placebos or standards of care). This paper highlights 2 recent reviews that explored what is known about CBL as it relates to medical education [11,12].

In 2000, Adler and Johnson [11] published a paper in Academic Medicine, a journal devoted to strengthening the quality of medical education and training. In this report, the authors used electronic databases to search for papers published between 1966 and 1998. Each pertinent article was categorized according to research design, type of journal, publication language, and year of publication.

The literature review resulted in 2,840 citations from nearly 750 journals. The number of citations increased over time, with approximately 180 citations per year by the mid-1990s. The vast majority (92%) were published in English, and 1,084 of these (43%) came from 25 of the journals (3.3%).

Adler and Johnson [11] further analyzed 1,071 citations for which abstracts were available. Sixty percent were uncontrolled demonstration articles that provided no comparison groups. There was no obvious trend in article categorization over the period studied. Most of the articles that compared methods of teaching compared traditional methods with CBL, although 9% of the studies compared 2 CBL methods. The authors concluded that articles describing CBL are predominantly descriptive in nature, with no comparison groups.

A more recent evaluation of CBL came from Letterie [12], who also performed a literature search. Only papers printed in English between 1998 and 2000 were considered. Key terms used in the search included computer-assisted instruction, medical education, computer aids, and a number of others. The bibliographies of all relevant papers were reviewed for references not identified in the original search.

Two hundred ten papers were identified, and the author performed content analysis on all papers. Reports were categorized according to study design, type of CBL (CD-ROM, video laser discs, web-based, etc), medical discipline (surgery, pediatrics, gynecology), and whether a measure of effectiveness was reported. In comparative studies, the author noted whether educational objectives were defined, if the study group was described, and whether appropriate statistical analysis was provided.

The results indicated that a variety of medical specialties were represented, with most papers describing educational efforts in internal medicine, radiology, and general surgery. The overwhelming majority of studies reviewed (96%) described a favorable impact of CBL on education, regardless of the reliability or rigor of the study design. Letterie [12] identified 126 studies (60%) that were completely noncomparative and descriptive. These 126 studies provided no information on learning gains or effectiveness, but all enthusiastically endorsed the new technology that was used.

Twenty-nine of the 210 papers were categorized as technology reviews. These papers summarized previously reported studies and offered suggestions on future applications. None of the reviews offered any critical evaluation (no measure of effectiveness was provided), but each review concluded that the future of technology within medical education was favorable. Thirty-two papers were editorial in nature, and 29 endorsed CBL as worthy of further study. In 3 cases, the editorialists offered cautious optimism and calls for further data. A need for a critical evaluation of CBL was expressed in only 2 editorials.

Of the 210 studies reviewed, only 23 (11%) were comparative in nature and included some form of assessment of effectiveness. The assessment method varied
widely, with some examples of pretesting and posttesting without comparison groups and other examples that used participant questionnaires to score program quality, without any measurement of performance. In all, only 12 studies were identified that compared traditional methods of instruction (textbook and lecture) with CBL by way of matched groups. Of these 12 studies, 5 indicated that CBL was associated with improved test performance, and the remainder found no difference between the groups. All of these studies endorsed CBL and reported that participants (medical students, residents) preferred CBL, in most cases without providing any data to support this preference.

**IS IT APPROPRIATE TO COMPARE CBL WITH TRADITIONAL FACE-TO-FACE METHODS?**

More than 10 years ago Friedman [13] argued that media-comparative research (in this case, comparing computer-based instructional formats with noncomputer-based formats) is “logically impossible because there is no true comparison group.” This view was restated very recently by Cook [14]. The argument that CBL should not be compared with noncomputer-based approaches is outlined briefly below.

Proponents of this argument aver that the analogy to clinical research using experimental and control groups is not apt. Clark [15] stated that such research requires “a uniform medium such as ‘computer’ which can be compared with some other uniform medium such as ‘teacher.’” In his recent paper, Cook [14] stated that this “uniformity does not exist” and indicated that many computer-based tutorials contain hypertext, multimedia, and interactive models that are not available in paper-based, traditional instruction. He also correctly pointed out that other variables (ease of access, screen size, scrolling) are operating in the CBL environment but not in the traditional lecture-based and paper-based environment. He argued that if a significant effect of CBL is found, it is impossible to know which component of the instructional program (hypertext, interactive models, etc) is responsible for the effect. Cook [14] also warned that these comparisons cannot be reliably generalized to other settings, because the multifactorial nature of CBL cannot be replicated precisely.

Cook [14] continued by reminding the reader that “ambiguity and unexplained variance limit the interpretations of results in any experimental study.” He acknowledged that participant variation (including unequal enthusiasm for different interventions) has been problematic in previous comparative trials of medical education but indicated that this variation can be addressed by careful study design. Variation within and among interventions using different media, however, cannot be accounted for in his view. He stated that “there are simply too many influential factors to allow the definition of an appropriate control intervention.” Given the potential for confounding inherent in media-comparative research, he told his readers that subsequent efforts should focus on comparisons of one form of CBL with another form of CBL. He concluded that CBL “is not a panacea, but holds great promise.”

Some summary statements on the use of computers in medical education are in order. Computer-based learning has been the subject of a relatively large number of citations. Most of these papers are descriptive in nature and provide no comparison groups. The number of articles that directly compare CBL with traditional methods is a small percentage of the total papers, and many of these comparison studies had methodologic weaknesses, i.e., no pretest or posttest knowledge assessment. Finally, despite the relative weakness of their study designs, the overwhelming majority of papers included enthusiastic endorsements of CBL. It is fair to say that the evidence demonstrating the effectiveness of CBL is weak and the evidence supporting the notion that CBL enhances learning—compared with traditional methods—is weaker still.

**ARE THERE NEGATIVE CONSEQUENCES TO INCORPORATING CBL INTO MEDICAL EDUCATION?**

This lack of evidence has not prevented many medical providers from aggressively incorporating personal computers into medical education. The majority of medical schools now require that all entering students own personal computers. There is some evidence that this requirement will undermine efforts to recruit a diverse medical student population [16]. In the remainder of this essay, I argue that the decision to use CBL in the place of face-to-face traditional instruction has important negative implications for stakeholders in medical education and may undermine the important role of patients in the education of doctors.

In 2004, more than 66,000 students were enrolled in medical schools in the United States [17]. As CBL and other technologic resources are increasingly used in the medical curriculum, it is possible that some students may be advantaged while others are disadvantaged. Very few of the publications admit that there may be winners and losers in CBL, although to their credit, Ward et al [7] warned that “there is a real danger that we could disenfranchise less affluent students.” As reported earlier, there is some evidence that requiring students to own personal computers will undermine efforts to recruit a diverse population [16].
Although there is a large literature on learning preferences and CBL in many other contexts, there is a dearth of literature that explores this relationship in medical students. A recent study evaluating the use of CBL in a basic-science medical school course revealed large disparities among individual medical student’s use of computer resources [18]. A later paper correlated medical students’ use of computers with personality preferences as measured by the Myers-Briggs Type Indicator test [19]. The students whose personality preferences were introverted, intuitive, thinking, and perceiving tended to use computers the most. The authors also concluded that using computers was not a natural inclination for many students. Additionally, there is some evidence that computer use and confidence in computer use differs according to gender [20]. If the introduction of the personal computer changes the culture of medical school to the benefit of some students over others, then educators must recognize this and consider whether these changes are a desirable consequence. At the very least, further research in this area is required.

As previously noted, the number of rigorous comparisons of CBL with traditional face-to-face methods is small. It should not be surprising, then, that the amount of published research that critically examines medical students’ attitudes toward computers and CBL is small. In one of the very few papers, Steele and colleagues [21] at the University of Nebraska explored medical students’ attitudes toward CBL before and after completing a CBL tutorial on angiography. The emphasis in this paper was self-reported students’ attitudes toward the computer as an educational tool. Medical students tended to have positive attitudes toward the angiography tutorial and felt that it was clear, organized, and easy to use. They also rated the tutorial as efficient and effective. The students did not, however, provide a broad endorsement for CBL. The majority of students indicated a preference for lecture-based and text-based learning. Qualitative interviews suggested that students were concerned that CBL would “supplant the student-teacher contact” that the students greatly valued.

Attending rounds, morning case conferences, and bedside teaching have been the centerpiece of medical education for more than a century. All of these activities are social in nature. These methods are entirely consistent with the theories of Vygotsky and others that hold that learning is a social activity and that knowledge is constructed through social interaction. Computer-based learning puts a premium on private learning and individual problem solving and undervalues group learning and cooperation. This approach is antithetical to the vision for a new health profession’s education outlined in the recent Institute of Medicine [1] monograph, in which collaboration, cooperation, and communication are emphasized.

More evidence that students may not desire CBL comes from a recent report by Hahne et al [22], from the University of Cologne Medical School. These authors examined learners’ attitudes toward CBL in the setting of a randomized trial of CBL. The authors reported that students’ attitudes toward CBL became more negative during the period of the study. The investigators warned that extending CBL into a larger portion of the medical curriculum may be “hampered by learner discouragement” associated with CBL. No qualitative comments were provided on the reasons why the students became more negative toward CBL.

Another group that stands to gain or lose with the introduction of CBL into the medical school curriculum is the faculty. Once again, there is precious little information relating to the attitudes of faculty members toward CBL. In one of the very few reports that has been published, Zayim et al analyzed survey responses from 155 medical faculty members in Turkey [23]. The results indicated very limited adoption of new educational technology by medical faculty members. Major barriers to broader adoption that were identified included inadequate hardware for students and faculty members, the lack of a reward structure, and insufficient training opportunities.

The importance of faculty training in educational technology was highlighted in a recent survey of faculty members at the University of Leicester in the United Kingdom [24]. The University of Leicester deployed the Blackboard Virtual Learning Environment in a limited manner in May 2002. The School of Biological Sciences was an early adopter and was the first to use the online assessment module of the Blackboard product. Badge et al [24] devised a survey and administered it to 47 faculty members at the school. The results indicated that the faculty members had largely rejected formal centralized training in the new technology and instead elected to teach themselves how to use the system. The result is that the system was used widely, but with minimal use of the more robust pedagogic elements. The faculty members used the system essentially as an electronic document repository. The authors concluded that “a large majority [of faculty members] fail to make use of the potential pedagogical advantages offered by the full functionality of the software.” Given the faculty members’ reluctance to attend training (fewer than 10% attended free sessions offered by the school), the authors opined that “it is unlikely that academic staff will be encouraged to attend similar sessions for pedagogic considerations of e-learning to improve their online teaching.”

It is axiomatic that the skills and attitudes of the teaching faculty members will influence the success of any new
technology that is incorporated into the medical education process. Most medical school faculty members have limited formal training in pedagogy and model their teaching after that of mentors or colleagues. The number of faculty members with firm understanding of how to use technology for educational purposes is even smaller. The 2004 AAMC [5] report emphasized that medical schools should require faculty members to periodically complete programs orienting them to the goals and objectives of the education program as a whole.

Ward et al [7] acknowledged medical faculty members will “resist changes in the way they work and teach.” If CBL is to succeed, significant investment in faculty training in novel educational methods will be required. The work of Daniel [25] has indicated that sending faculty members to “generic” workshops designed to improve their skills with educational technologies may not be worthwhile, because many of these faculty members may not know where to start and may feel that their time is not being well spent. The experience from the University of Leicester described above suggests that even institutional support does not guarantee success.

Finally, it is at least possible that CBL will erode the important role of patients in medical education. As Ludmerer and Johns [26] reminded us in a recent article, one of the founding educational principles at the heart of medical education is the assumption of responsibility by students and residents for patient management. A person cannot acquire the skills necessary to be a competent physician without caring for patients and learning from them. Students and residents are expected to evaluate patients themselves, make decisions about diagnosis and therapy themselves, and perform their own procedures and treatments. Of course, students and residents ought to be supervised and accountable to attending physicians, with the level of supervision graded according to a trainee’s experience.

In a recent review of how computers can be used in medical education, Devitt and Palmer [27] reported that patients are now “less accessible as a learning resource.” They provided no reference to support this dubious claim, but it is the next sentence that is most chilling to this reader. They speculated that “perhaps the computer can be used to simulate the doctor-patient and teacher-student relationship.” Why is this statement chilling? Allow me to explain.

The Institute of Medicine has defined 5 core competencies that all clinicians should possess to meet the needs of the 21st-century health system. First among these competencies is the ability to provide patient-centered care. This competency requires that physicians (and any health care professionals) identify, respect, and care about patients’ values, preferences, and expressed needs. I take the position that medical students and residents can learn about patients’ values, preferences, and expressed needs only from interacting with patients directly. A computer is no substitute for a human being!

A similar sentiment is presented in a recent book by social critic and sociologist Neil Postman [28]. In the portion of his book examining computer technology, Postman described the anthropomorphic language surrounding computers as a “metaphor gone mad.” He sees that the American culture has moved from “the proposition that humans are in some respects like machines . . . to the proposition that humans are little else but machines and, finally, that human beings are machines.” The final jump is to the proposition that a machine (in this case a personal computer) is a human being. I hope that the zeal for new technology will not overwhelm medical educators and produce a system that neglects the most valuable resource in medical education, our patients.

CONCLUDING THOUGHTS

The recent AAMC [5] report states that one of the properties of an ideal medical education system is that it will promote “a humanistic approach to medicine” and “a patient centered approach to medical care.” In the AAMC’s “Strategic Plan” from 1995 can be found the following statement: “The AAMC should stimulate changes in medical education to create a better alignment of educational content and goals with evolving social needs, practice patterns, and scientific developments.” It may not be wise for medicine to be that responsive to some elements of society, especially if in so doing we ignore the humanity of the patients from whom we learn.

The intent of this article is not to argue that the use of computers within medical education is a universally bad idea. The use of computer simulations to educate and train physicians to perform high-risk invasive procedures is a fine example of how computers can be responsibly integrated into medical education. Nor do I hold the position that CBL is always a poor educational strategy. A recent rigorous randomized trial suggested that the personal computer (and the World Wide Web) may be an important educational tool for physicians to obtain continuing medical education credits [29]. The 2 take-home points from this essay can be concisely stated as follows: (1) the evidence that CBL is as good as or superior to traditional medical educational methods is weak, and (2) the introduction of CBL into medical education may have significant negative consequences for students, faculty members, and the doctor-patient relationship. As responsible educators, let us recognize that newer is not always better and that replacing people (as teachers or patients) with computers can have negative consequences.
REFERENCES


