The Impact of E-Learning in Medical Education

Jorge G. Ruiz, MD, Michael J. Mintzer, MD, and Rosanne M. Leipzig, MD, PhD

Abstract

The authors provide an introduction to e-learning and its role in medical education by outlining key terms, the components of e-learning, the evidence for its effectiveness, faculty development needs for implementation, evaluation strategies for e-learning and its technology, and how e-learning might be considered evidence of academic scholarship.

E-learning is the use of Internet technologies to enhance knowledge and performance. E-learning technologies offer learners control over content, learning sequence, pace of learning, time, and often media, allowing them to tailor their experiences to meet their personal learning objectives. In diverse medical education contexts, e-learning appears to be at least as effective as traditional instructor-led methods such as lectures. Students do not see e-learning as replacing traditional instructor-led training but as a complement to it, forming part of a blended-learning strategy. A developing infrastructure to support e-learning within medical education includes repositories, or digital libraries, to manage access to e-learning materials, consensus on technical standardization, and methods for peer review of these resources. E-learning presents numerous research opportunities for faculty, along with continuing challenges for documenting scholarship. Innovations in e-learning technologies point toward a revolution in education, allowing learning to be individualized (adaptive learning), enhancing learners' interactions with others (collaborative learning), and transforming the role of the teacher. The integration of e-learning into medical education can catalyze the shift toward applying adult learning theory, where educators will no longer serve mainly as the distributors of content, but will become more involved as facilitators of learning and assessors of competency.

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Today's medical educators are facing different challenges than their predecessors in teaching tomorrow's physicians. In the past few decades, changes in health care delivery and advances in medicine have increased demands on academic faculty, resulting in less time for teaching than has previously been the case.[1] Changes in sites of health care delivery, from acute care institutions to community-based settings for chronic care, have required adaptations in educational venues.[2] Finding time to teach "new" fields such as genomics, palliative care, geriatrics, and complementary medicine is difficult when medical school curricula are already challenged to cover conventional materials.[1] Traditional instructor-centered teaching is yielding to a learner-centered model that puts learners in control of their own learning. A recent shift toward competency-based curricula emphasizes the learning outcome, not the process, of education.[3]

E-learning refers to the use of Internet technologies to deliver a broad array of solutions that enhance knowledge and performance.[4,5] E-learning can be used by medical educators to improve the efficiency and effectiveness of educational interventions in the face of the social, scientific, and pedagogical challenges noted above. It has gained popularity in the past decade; however, its use is highly variable among medical schools and appears to be more common in basic science courses than in clinical clerkships.[6,7]

In this article, we review the current state of e-learning in medical education by outlining the following: key terms, the components of e-learning, the evidence for its effectiveness, faculty development needs for implementing e-learning, evaluation strategies for e-learning and its technology, and the potential for e-learning to be considered evidence of academic scholarship.

Definitions

E-learning is also called Web-based learning, online learning, distributed learning, computer-assisted instruction, or Internet-based learning. Historically, there have been two common e-learning modes: distance learning and computer-assisted instruction. Distance learning uses information technologies to deliver instruction to learners who are at remote locations from a central site. Computer-assisted instruction (also called computer-based learning and computer-based training) uses computers to aid in the delivery of stand-alone multimedia packages for learning and teaching.[7] These two modes are subsumed under e-learning as the Internet becomes the integrating technology.

A concept closely related to e-learning but preceding the birth of the Internet is

Dr. Ruiz is assistant professor of clinical medicine, Division of Gerontology and Geriatric Medicine, University of Miami Miller School of Medicine, Miami, Florida; associate director for education/evaluation, Geriatric Research, Education, and Clinical Center, VA Medical Center, Miami, Florida; and senior investigator, Stein Gerontological Institute, Miami, Florida.

Dr. Mintzer is associate professor of clinical medicine, Division of Gerontology and Geriatric Medicine, University of Miami Miller School of Medicine, Miami, Florida; director, Community Academic Partnerships, and investigator, Geriatric Research, Education, and Clinical Center, VA Medical Center, Miami, Florida; and senior investigator, Stein Gerontological Institute, Miami, Florida.

Dr. Leipzig is professor, Department of Geriatrics and Adult Development; and vice chair for education, Brookdale Department of Geriatrics and Adult Development, Mount Sinai School of Medicine, New York, New York.

Correspondence should be addressed to Dr. Ruiz, VA Medical Center, GRECC (11GRC), 1201 NW 16th Street, Miami, FL 33125; telephone: (305) 575-3388; fax: (305) 575-3365; e-mail: ⟨jruiz2@med.miami.edu⟩.

multimedia learning. Multimedia uses two or more media, such as text, graphics, animation, audio, or video, to produce engaging content that learners access via computer. Blended learning, a fairly new term in education but a concept familiar to most educators, is an approach that combines e-learning technology with traditional instructor-led training, where, for example, a lecture or demonstration is supplemented by an online tutorial.[8]

Faculty, administrators, and learners find that multimedia e-learning enhances both teaching and learning. These advantages can be categorized as targeting either learning delivery or learning enhancement.

Learning delivery is the most often cited advantage of e-learning and includes increased accessibility to information, ease in updating content, personalized instruction, ease of distribution, standardization of content, and accountability.[4,5] Accessibility refers to the user's ability to find what is needed, when it is needed. Improved access to educational materials is crucial, as learning is often an unplanned experience.[5,7] Updating electronic content is easier than updating printed material[9]: e-learning technologies allow educators to revise their content simply and quickly. Learners have control over the content, learning sequence, pace of learning, time, and, often, media, which allows them to tailor their experience to meet personal learning objectives.[10] Internet technologies permit the widespread distribution of digital content to many users simultaneously anytime and anywhere.

An additional strength of e-learning is that it standardizes course content and delivery; unlike, for instance, a lecture given to separate sections of the same course. Automated tracking and reporting of learners' activities lessen faculty administrative burden. Moreover, e-learning can be designed to include outcomes assessment to determine whether learning has occurred.[11]

Advantages in learning enhancement are a less well recognized but potentially more revolutionary aspect of e-learning than are those related to learning delivery. E-learning technologies offer educators a new paradigm based on adult learning theory, which states that adults learn by relating new learning to past experiences, by linking learning to specific needs, and by practically applying learning, resulting in more effective and efficient learning experiences.[11] Learning enhancement permits greater learner interactivity and promotes learners' efficiency, motivation, cognitive effectiveness, and flexibility of learning style. Learning is a deeply personal experience: we learn because we want to learn. By enabling learners to be more active participants, a well-designed e-learning experience can motivate them to become more engaged with the content.[12] Interactive learning shifts the focus from a passive, teacher-centered model to one that is active and learner-centered, offering a stronger learning stimulus. Interactivity helps to maintain the learner's interest and provides a means for individual practice and reinforcement. Evidence suggests that e-learning is more efficient because learners gain knowledge, skills, and attitudes faster than through traditional instructor-led methods. This efficiency is likely to translate into improved motivation and performance.[12] E-learners have demonstrated increased retention rates and better utilization of content, resulting in better achievement of knowledge, skills, and attitudes.[12] Multimedia e-learning offers learners the flexibility to select from a large menu of media options to accommodate their diverse learning styles.[12]

Components of E-Learning

Creating e-learning material involves several components: once content is developed, it must be managed, delivered, and standardized.

Content comprises all instructional material, which can range in complexity from discrete items to larger instructional modules. A digital learning object is defined as any grouping of digital materials structured in a meaningful way and tied to an educational objective.[13] Learning objects represent discrete, self-contained units of instructional material assembled and reassembled around specific learning objectives, which are used to build larger educational materials such as lessons, modules, or complete courses to meet the requirements of a specified curriculum.[14] Examples include tutorials, case-based learning, hypermedia, simulations, and game-based learning modules. Content creators use instructional design and pedagogical principles to produce learning objects and instructional materials.

Content management includes all the administrative functions (e.g., storing, indexing, cataloging) needed to make e-learning content available to learners. Examples include portals, repositories, digital libraries, learning-management systems, search engines, and ePortfolios. A learning-management system, for example, is Internet-based software that facilitates the delivery and tracking of e-learning across an institution.[15,16] A learning-management system can serve several functions beyond delivering e-learning content. It can simplify and automate administrative and supervisory tasks, track learners' achievement of competencies, and operate as a repository for instructional resources twenty-four hours a day.[15,16] Learning-management systems familiar to medical educators are WebCT® or Blackboard®, but there are more than 200 commercially available systems, a number that is growing rapidly.

Content delivery may be either synchronous or asynchronous.[5] Synchronous delivery refers to real-time, instructor-led e-learning, where all learners receive information simultaneously and communicate directly with other learners. Examples include teleconferencing (audio, video, or both), Internet chat forums, and instant messaging. With asynchronous delivery, the transmission and receipt of information do not occur simultaneously. The learners are responsible for pacing their own self-instruction and learning. The instructor and learners communicate using e-mail or feedback technologies, but not in real time. A variety of methods can be used for asynchronous delivery, including e-mail, online bulletin boards, listservs, newsgroups, and Weblogs.

In addition to establishing, managing, and delivering content, a fourth component is part of the e-learning equation. It is becoming increasingly clear that standards are needed for the creation of new e-learning material.[17] Such standards promote compatibility and usability of products across many computer systems, facilitating the widespread use of e-learning materials.

Several organizations have been engaged in creating broad e-learning standards.[17] Although not specifically designed for medical education, these standards offer medical educators important advantages. The most well-known set of standards is the Advanced Distributed Learning: Sharable Content Object Reference Model (SCORM). SCORM is a group of specifications developed through a collaborative effort of e-learning organizations funded by the United States Department of Defense.[17] SCORM specifications prescribe the manner in which a learning-management system handles e-learning products.[17] E-learning material built to SCORM specifications will interact with a conformant learning-management system, allowing for the prescription of the learning experience and tracking of learner performance. In medical education, MedBiquitous, a consortium of academic, government, and health care industry organizations, is working to develop SCORM-compliant specifications and standards for medical education.[18]

The Evidence for Effective and Efficient E-Learning

The effectiveness of e-learning has been demonstrated primarily by studies of higher education, government, corporate, and military environments.[11,19] However, these studies have limitations, especially because of the variability in their scientific design.[19,20] Often they have failed to define the content quality, technological characteristics, and type of specific e-learning intervention being analyzed. In addition, most have included several different instructional and delivery methodologies, which complicates the analysis.[21] Most of these studies compared e-learning with traditional instructor-led approaches.[15,19]

Yet three aspects of e-learning have been consistently explored: product utility, cost-effectiveness, and learner satisfaction. Utility refers to the usefulness of the method of e-learning. Several studies outside of health care have revealed that most often e-learning is at least as good as, if not better than, traditional instructor-led methods such as lectures in contributing to demonstrated learning.[5,11] Gibbons and Fairweather[11] cite several studies from the pre-Internet era, including two meta-analyses that compared the utility of computer-based instruction to traditional teaching methods. The studies used a variety of designs in both training and academic environments, with inconsistent results for many outcomes. Yet learners' knowledge, measured by pre-post test scores, was shown to improve. Moreover, learners using computer-based instruction learned more efficiently and demonstrated better retention.

Recent reviews of the e-learning (specifically Web-based learning) literature in diverse medical education contexts reveal similar findings.[22] Chumley-Jones and colleagues[22] reviewed 76 studies from the medical, nursing, and dental literature on the utility of Web-based learning. About one-third of the studies evaluated knowledge gains, most using multiple-choice written tests, although standardized patients were used in one study. In terms of learners' achievements in knowledge, Web-based learning was equivalent to traditional methods. Of the two studies evaluating learning efficiency, only one demonstrated evidence for more efficient learning via Web-based instruction.[22]

A substantial body of evidence in the nonmedical literature has shown, on the basis of sophisticated cost analysis, that e-learning can result in significant cost-savings, sometimes as much as 50%, compared with traditional instructor-led learning.[11] Savings are related to reduced instructor training time, travel costs, and labor costs, reduced institutional infrastructure, and the possibility of expanding programs with new educational technologies.[11] Only one study in the medical literature evaluated the cost-effectiveness of e-learning as compared with text-based learning. The authors found the printing and distribution of educational materials to be less costly than creating and disseminating e-learning content.[22]

Studies in both the medical and nonmedical literature have consistently demonstrated that students are very satisfied with e-learning.[11,22] Learners' satisfaction rates increase with e-learning compared to traditional learning, along with perceived ease of use and access, navigation, interactivity, and user-friendly interface design.[11,22] Interestingly, students do not see e-learning as replacing traditional instructor-led training but as a complement to it, forming part of a blended-learning strategy.[11,22]

Availability of E-Learning Resources

Thanks to the growth of educational technologies and the Internet, the number of e-learning resources available to educators has dramatically increased. Within medical education, repositories or digital libraries have been established to manage access to e-learning materials. Although few at this time, such repositories offer a vision of expanded access to a large number of high-quality, peer-reviewed, sharable e-learning materials (see Table 1). Examples include the Association of American Medical Colleges' (AAMC's) MedEdPortal, a repository for curriculum and assessment materials organized around core competencies in medical education and populated with up-to-date, peer-reviewed teaching and assessment materials.[23] The End of Life/Palliative Education Resource Center is a free-access repository of digital content for health profession educators involved in palliative care education.[24] The Health Education Assets Library (HEAL) provides high-quality digital materials for health sciences educators[25] and promotes the preservation and exchange of useful educational assets such as individual graphic, video, or audio elements, while respecting ownership and privacy. HEAL has begun a peer-review process for all e-learning materials submitted to the library.[25] The Multimedia Educational Resource for Learning and Online Teaching (MERLOT) is designed primarily for faculty and students of higher education.[26] The service collects links to online learning materials, along with annotations such as users' reviews and assignments. MERLOT contains a growing science and technology section that includes health care education e-learning materials.[26] The International Virtual Medical School (IVIMEDS) is an international organization whose mission is to set new standards for e-learning in medical education through a partnership of medical schools and institutions, using a blended-learning approach. IVIMEDS hosts a repository for use by its member medical schools.[27] Most of the materials in this repository are free to use, although some materials have clearly defined conditions for use. In the future, these

Table 1
Medical Education Organizations Supporting E-Learning

Organization	Characteristics
MedEdPortal, Association of American Medical Colleges (AAMC) ⟨http://www.aamc.org/meded/mededportal/⟩	Repository All digital content types Material linked to educational competencies Peer reviewed "Virtual patients" bank
End of Life/Palliative Education Resource Center (EPERC) ⟨http://www.eperc.mcw.edu/⟩	Repository Digital content in end-of-life issues Peer reviewed Links to other online resources
The Health Education Assets Library (HEAL) ⟨http://www.healcentral.org⟩	Repository Large number of learning assets Growing number of learning objects Peer reviewed
Multimedia Educational Resource for Learning and Online Teaching (MERLOT) ⟨http://www.merlot.org⟩	Repository for higher education Links to other online resources with peer-review comments Growing science and technology section
International Virtual Medical School (IVIMEDS) ⟨http://www.ivimeds.org/⟩	A consortium of medical schools Setting standards in medical education Repository for member schools Partnerships Blended learning

and other repositories may require a membership or other fees to cover the ongoing expenses of Web-site maintenance.

Evaluating E-Learning Processes and Outcomes

Adopting e-learning and its technology requires large investments in faculty, time, money, and space that need to be justified to administrators and leadership. As with other educational materials, there are two major approaches to the evaluation of e-learning: process and outcomes.

Process evaluation examines an e-learning program's strengths and weaknesses and how its results are produced, often providing information that will allow others to replicate it. Peer review is one type of process evaluation. Traditional peer review for journal articles verifies the quality of content. E-learning requires the consideration of additional dimensions. For example, is it easy to "navigate" through the online material? Is the appearance conducive to education? Are multimedia elements used effectively? Is the interactivity appropriate for the level of the learner? Are special computer skills, hardware, or software required? These and other questions place new demands on peer reviewers engaged in process evaluation of e-learning. In fact, the AAMC, at the request of the Council of Deans, has begun a peer-review process of e-learning that recognizes these materials as evidence of scholarly activity for faculty promotion and recognition.[28]

Outcome evaluation of changes in learners' knowledge, skills, or attitudes allows e-learning developers to gauge program effectiveness. The evaluation framework outlined by Kirkpatrick[29] in the 1950s and later adapted to health care education[30] can be used to evaluate e-learning interventions.[31] The Kirkpatrick model defines four levels of evaluation based on outcome: satisfaction, learning, change in learner behavior, and organizational change/patient outcome.

Satisfaction measures learners' reactions to the material: was it easy to use, hard to use, fun, boring, and so forth. But satisfaction measures alone do not measure learning. For example, excellent content that learners find difficult to use may be rated as poor. Likewise, a module that is highly entertaining in its use of multimedia but superficial in its content may be rated as excellent.

Tracking and monitoring learners' knowledge, attitudes, and skills via a learning-management system can greatly simplify the process of evaluating the gains made through e-learning. An approach that combines assessment of skills and attitudes using e-learning technology with facilitator-mediated observation would allow a more in-depth evaluation of skills and behavior. By contrast, evaluating the direct result of an education program by measuring changes in learners' behaviors, institutional changes, and better patient care is often complex, time-consuming, and costly. E-learning assessments can be one valuable component in such overall evaluation of medical school curricula.

E-Learning as Academic Scholarship

The literature regarding faculty development or promotion of e-learning as evidence of scholarly pursuit is almost nonexistent to our knowledge; however, as noted above, e-learning requires faculty competencies that go beyond traditional instructional activities. Furthermore, by its nature, e-learning offers learners and instructors the possibility of widespread use, access, and sharing unmatched by other types of instruction. Evaluation data from peer review as well as learning-management system tracking and monitoring of e-learning use can provide evidence of its quality and effectiveness. How are faculty members recognized and rewarded for their dedication to this effort? The following activities could be considered evidence of scholarship for faculty promotion:

- Publication of e-learning materials in a national online peer-reviewed repository.
- Faculty and learner evaluations of one's e-learning material.
- Peer-reviewed publications describing the process, impact, and scientific contributions of e-learning to medical education.
- Successful grant awards in e-learning.
- Participation in national (and international) societies concerned with

the development, application, and use of e-learning in medical education.

Numerous research opportunities exist in the relatively new field of e-learning. Faculty, administrators, and the public will demand that educators evaluate the impact of e-learning on the quality and efficiency of medical education. Extrapolating methods from other clinical and educational research, including comparative studies, is insufficient because such studies often ignore the complexity of the learning process and the methods of delivery characteristic of e-learning. Potential areas for research include assessing contexts for effective use of e-learning in medical education, the differential use of e-learning in preclinical versus clinical years, the adaptation of e-learning to a wide variety of medical specialties and clinical settings, an exploration of methods for simplifying the e-learning creation process to gain wider acceptance and use, the incorporation of e-learning as part of a blended-learning strategy, and the use of a multimedia instructional design process by medical educators.

Integrating E-Learning into Medical Education

The integration of e-learning into existing medical curricula should be the result of a well-devised plan that begins with a needs assessment and concludes with the decision to use e-learning.[32] Although some institutions have tried to use e-learning as a stand-alone solution to updating or expanding their curricula, we believe it is best to begin with an integrated strategy that considers the benefits and burdens of blended learning before revising the curriculum. In undergraduate medical education, e-learning offers learners materials for self-instruction and collaborative learning. In graduate medical education, the Accreditation Council for Graduate Medical Education has established six core competencies toward which e-learning can be applied. E-learning materials suited for each of these competencies can be integrated into the education of residents and fellows, replacing lectures and other synchronous methods of instruction. Asynchronous e-learning can be effectively used during demanding clinical care rotations, especially when duty hours are limited yet curriculum requirements remain high. In continuing medical education, physicians with daily clinical obligations can attend medical "e-conferences" using e-learning.

The complexity and breadth of medical education content, together with the scarcity of experts and resources in e-learning, make the creation of centers of excellence in e-learning a reasonable proposition. The Federal Interagency Working Group on Information Technology Research and Development has recommended the establishment of centers to explore "new delivery modes for educating medical practitioners and providing continuing medical education"[33]; e-learning clearly fits that description. Such centers could offer a wide range of services, including system deployment and administration, training of faculty and administrators, assistance in content development, the design of learning pathways and programs, marketing and support, supervision, maintenance, research, and consultation.

The Internet2 is a U.S.-based, collaborative, university-led project started in 1996 to develop additional infrastructure for the Internet backbone capable of superhigh bandwidth.[34] The Internet2's vision of extremely fast speed, complex real-time multimedia capabilities, and quality of service would provide educators enormous potential to enhance the learning experience.[34] Larger bandwidth offers the promise of sophisticated immersive simulations and the use of full-motion video in real time, in both asynchronous and synchronous modes of instruction, delivered to any desktop computer.[35] Many medical schools and health care organizations are already producing high-fidelity e-learning materials, such as virtual patient simulations, that could soon be within the reach of any educator and learner.[35–37]

Directions for the Future

Developments in e-learning and technologies are creating the groundwork for a revolution in education, allowing learning to be individualized (adaptive learning), enhancing learners' interactions with each other (collaborative learning), and transforming the role of the teacher (from disseminator to facilitator).

Adaptive learning uses technology to assess learners' knowledge, skills, and attitudes at the beginning of online training in order to deliver educational materials at the level most appropriate for each learner.[11] In the online environment of e-learning, adaptive learning is possible through identification of the learner, personalization of content, and individualization of tracking, monitoring, support, and assessment.[11,21] Adaptive learning is the ultimate learner-centered experience because it individualizes a unique learning path for each learner that is likely to target his or her specific learning needs and aptitudes.

The potential for collaborative learning to break the isolation of learners is realized in e-learning technologies. Advances in synchronous distance education and collaborative technologies like Weblogs, message boards, chats, e-mail, and teleconferencing are making such collaborative learning more readily available. Quantitative and qualitative studies of collaborative learning in medicine have shown higher levels of learner satisfaction, improvements in knowledge, self-awareness, understanding of concepts, achievement of course objectives, and changes in practice.[38,39]

An evolving emphasis within medical education on lifelong learning and competency-based education has forced educators to reevaluate their traditional roles.[10] In this changing paradigm, educators no longer serve as the sole distributors of content, but are becoming facilitators of learning and assessors of competency. E-learning offers the opportunity for educators to evolve into this new role by providing them with a set of online resources to facilitate the learning process.[10]

Summary

E-learning refers to the use of Internet technologies to deliver a broad array of learning modes that enhance learners' knowledge and performance. There is evidence for the effectiveness and acceptance of e-learning within the medical education community, especially when combined with traditional teacher-led activities in a blended-learning educational experience. Several digital repositories of e-learning materials exist, some with peer review, where instructors or developers can submit materials for widespread use or retrieve them for

creating new materials. The evaluation of e-learning should include a peer-review process and an assessment of outcomes such as learner satisfaction, content usability, and demonstration of learning. Faculty skills in creating e-learning may differ from those needed for traditional teaching; faculty rewards for scholarly activity must recognize this difference and should be commensurate with effort. With technological advancement, the future offers the promise of high-fidelity, high-speed simulations and personalized instruction using both adaptive and collaborative learning. Centers of excellence in e-learning can provide national support for the design, development, implementation, evaluation, collaboration, and sharing of digital e-learning materials. The integration of e-learning into undergraduate, graduate, and continuing medical education will promote a shift toward adult learning in medical education, wherein educators no longer serve solely as distributors of content, but become facilitators of learning and assessors of competency.

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