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A Review of e-Learning Practices for Undergraduate Medical Education

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This paper describes the findings of a literature review conducted on the current usage, lessons, and limitations of e-learning for undergraduate medical education with an emphasis on synchronous delivery in the first 2 years. The review was conducted as part of an initiative to expand the UBC undergraduate medical program in British Columbia, Canada. The 50 e-learning articles included in the review described the deployment of various types of e-learning technology and content in different settings. The seven videoconferencing articles provided product information, health education examples, and innovative approaches. The six review articles provided general guidelines and trends on e-learning in undergraduate medical education in United States and Europe. Overall, while the literature is informative, there are few reported studies that address distributed synchronous learning in these undergraduate programs.

KEY WORDS: e-learning; undergraduate; medical education; distributed program.

INTRODUCTION

Purpose of Review

An initiative is underway in the Faculty of Medicine at the University of British Columbia (UBC) in Canada to expand into a distributed undergraduate medical program in partnership with the University of Victoria (UVic) and the University of Northern British Columbia (UNBC).[4] The design of this distributed model is to deliver most of the first 2 years of the MD undergraduate program at the collaborating university campuses supported by information and communications technology (ICT). Although a common perception is that many medical schools are currently on

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the e-learning[5] bandwagon, it is not clear to what extent these schools have adopted such technology, how it is being used, the type of online content being developed, and the lessons learned. This paper describes the findings of a literature review conducted as part of our expansion initiative to examine the current use, lessons, and limitations of e-learning for undergraduate medical education with an emphasis on synchronous delivery in the first 2 years.

Background and Context

Approximately one-third of Canadians live in rural communities of 10,000 people or less. However, only 19% of general practitioners and 4% of specialist physicians practice in rural areas.(1) Furthermore, the Canadian Medical Association projections provide scenarios to 2021 that are "frighteningly dismal and predict an aging, shrinking stock of rural physicians." A realistic estimate of medical graduates heading into rural practice indicates that numbers will not even keep pace with the current shortfall, let alone close the access gap between rural and urban communities.(2) Like Canada, USA and Australia both experience shortages of physicians in rural remote and northern areas.

Recently, attention has turned to the potential to increase recruitment to these understaffed areas by shifting admissions processes and by increasing the exposure of undergraduate and postgraduate medical students to these underserved areas during their education.(3) Common elements of programs that are successful in training graduates that practice in rural areas include early and sustained contact with rural communities, and sustained exposure to physician as role models and mentors within these communities. Medical schools and undergraduate medical education programs located outside urban areas are more likely to succeed in graduating physicians who choose to practice in rural areas and recruiting graduates to rural areas.(4–7)

For this reason, a number of established medical schools utilize a distributed model of undergraduate medical education in order to increase undergraduate student exposure to rural and remote communities. For example, the WWAMI program at the University of Washington has a long history of a distributed program with partnered universities in other states and distributed core clinical education.(8) To date these programs are described as being rooted in rural clinical experience, and the potential contribution of e-learning to enable distributed undergraduate medical education into nonurban geographical settings has not been reported.

The aim of the UBC undergraduate medical program expansion in partnership with UVic and UNBC is to encourage physician graduates to practice in rural communities after their training. The distributed program also allows sharing of faculty and resources locally as a means of building capacity at partner universities. Although the undergraduate curriculum is centred around problem-based learning, 20–30% of the curriculum is still being delivered as lectures and case presentations in large group classroom settings. As such, the use of ICT is seen as an essential component of the distributed program with its ability to provide high quality

[5]e-Learning is broadly defined as the use of ICT to provide online education and training.

online medical content and synchronous instructional delivery across multiple sites in real time.

REVIEW APPROACH

Literature Sources

Our search was limited to PubMed and Abstracts of Business Index (ABI) using common e-learning terms to provide an initial sense of the landscape and authors/institutions for follow up. The PubMed was searched using the terms e-learning, undergraduate medical education, distance and Internet covering 1997–2002, where 128 articles were returned. A second search with the terms videoconferencing, medical and education for the same period returned 13 other articles. The ABI was searched using the terms videoconferencing and education, where up to 40 recent articles were retrieved. Another 12 articles/reports from previous collections and journal/website scans were included. The search led to a total of 193 articles and reports.

Methods of Analysis

Only articles aimed at undergraduate medical education were considered. Using this criterion, 50 primary e-learning articles, 6 e-learning review articles, and 7 videoconference articles were included in the review. An alphabetical listing of these 63 articles is in Appendix A. The findings in terms of reported current usage were categorized by seven themes that we felt were relevant to our expansion initiative:

- e-Learning by type of study—the research approaches used are grouped by study design
- e-Learning by type of technology—the technologies used are grouped by type
- e-Learning by type of learner—the types of medical students cited in the articles
- e-Learning by subject area—the topics for which technology/content were developed
- e-Learning by learning activity—the modalities used to deliver the curriculum
- Use of videoconferencing—the use of videoconferencing to deliver the curriculum
- e-Learning guidelines and trends—general technology guidelines and trends reported.

SUMMARY OF FINDINGS

e-Learning by Type of Study

Of the 50 primary articles, those with details on research design, student subjects, and evaluation results are considered higher quality and grouped under evaluation

Table I. Articles Tabulated According to the Type of Study Reported

Type of study	Authors (see Appendix for details)	Count
Descriptive report	Bacro, 1997; Bacro, 2000; Baker, 2001; Baldwin, 2001; Cameron, 1999; Chen, 1998; Davis, 2001; Dev, 2000; Dornan, 2001; Eysenbach, 1998; Gorbis, 1999; Gorby, 2001; Hagdrup, 1999; Hodgson, 2001; Kaelber, 2001; Konstan, 1997; Locke and Lun, 1998; Martens, 2001; Parker and Seifter, 2001; Relan, 2001; Riza, 2001; Sarkowski, 2001; Soula, 2001; Steinberg, 2002; Uijdehaage, 2001; White, 2001	26 (52%)
Evaluation study		
RCT, control/test groups	Baumlin, 2000; Devitt and Palmer, 1999; Gul, 1999a,b; Mehrabi, 2000; Mehta, 1998	6 (12%)
Pre/postcohort groups	Grundman, 2000; Kim, 2001; Magee, 2001; Swagerty, 2000	4 (8%)
Follow-up questionnaire	Baer and Chamberlain, 1998; Devitt and Palmer, 1998; Harris, 2001; Richardson, 1997	4 (8%)
Interviews/focus groups	Gray, 2000a,b; Hunter, 2000; Teague, 2000	4 (8%)
Usage/observations	Lehmann, 1999; Platt, 1999; Schaad, 1999; Srinivasan, 2002	4 (8%)
Longitudinal surveys	Broudo, 1999	1 (2%)
Content review	Korin, 2001	1 (2%)

study, whereas articles lacking such information are labelled as descriptive reports only. Of the 50 articles, 26 or 52% are descriptive in nature, even though many included informal assessment of their content and technology. The lack of study design details made it difficult to judge the quality of these descriptive reports. The 24 evaluation studies used different evaluation methods that consisted of controlled trials, follow-up questionnaires, pre/postcohort assessment, interviews and focus groups, system usage and observations, longitudinal surveys, and content review. Evaluation measures were mostly around user satisfaction, actual usage, subjective feedback, and student performance. The types of study reported by the articles are summarized in Table I. Overall, the evaluation results are generally favorable but not readily comparable due to the different technologies, content, subjects, and measures used. Ten evaluation studies of acceptable quality with the use of controlled or pre/postcohort groups are included in Appendix B to illustrate the diversity of the design, technology, subjects, and results reported. Meta-analysis was not done since most reported only frequencies and percentages with little statistical data included.

e-Learning by Type of Technology

The types of technology reported include Web-based platforms, Internet connectivity tools, streaming video, interactive CDs, videoconference, and specialized software. The respective technologies used are summarized in Table II. Thirty-three of the 50 primary articles (66%) focused on Web-based platforms to provide curriculum related content; some of these platforms included more advanced features such as digitized images, simulated cases, videos and self-assessment. Seven articles reported the use of specialized software such as simulation modeling that run on PCs or in local computer labs. Four articles focused on establishing Inter-

Table II. Articles Tabulated According to the Type of Technology Reported

Type of technology	Authors (see Appendix for details)	Count
Web-based platform	Bacro, 1997; Baer and Chamberlain, 1998; Baker, 2001; Baldwin, 2001; Baumlin, 2000; Broudo, 1999; Dornan, 2001; Eysenbach, 1998; Gray, 2000a,b; Grundman, 2000; Hagdrup, 1999; Harris, 2001; Hodgson, 2001; Hunter, 2000; Kaelber, 2001; Kim, 2001; Konstan, 1997; Korin, 2001; Locke and Lun, 1998; Magee, 2001; Martens, 2001; Mehta, 1998; Parker and Seifter, 2001; Relan, 2001; Riza, 2001; Sarkowski, 2001; Schaad, 1999; Soula, 2001; Srinivasan, 2002; Steinberg, 2001; Swagerty, 2000; Uijdehaage, 2001	33 (66%)
Specialized software	Davis, 2001; Devitt and Palmer, 1999; Devitt and Palmer, 1998; Gorby, 2001; Lehmann, 1999; Mehrabi, 2000; Richardson, 1997	7 (14%)
Internet connectivity tools	Cameron, 1999; Chen, 1998; Platt, 1999; Teague, 2000; White, 2001	5 (10%)
Videos on CD, link to Web	Bacro, 2000; Gorbis, 1999	2 (4%)
Videoconference	Gul, 1999a,b	2 (4%)
Streaming video	Dev, 2000	1 (2%)

Note. The 10 quality evaluation studies with controlled or pre/postcohort groups are italicized.

net connectivity such as e-mail and bulletin boards for students on clinical clerkships. Note that only two articles (4%) described the use of videoconferencing for synchronous small group teaching; most of the remaining articles (96%) were aimed at asynchronous delivery of the curriculum through online content to enhance self-learning by students or to supplement traditional classroom/lab sessions by instructors. When sorted by technology, the 10 quality evaluation studies listed in Appendix B showed favorable user satisfaction and feedback, but variable system usage and student performance. In particular, the two videoconferencing studies for surgery demonstrations had much higher satisfaction ratings and preferences by students than being physically present at the operating theatres. No improvement in test/exam scores was found in three of the other seven studies that compared student performance.

e-Learning by Type of Learner

The 50 primary articles covered medical students in both preclinical and clinical years. Close to half of the articles (48%) involved 1st and 2nd year students, 13 articles (26%) involved clinical clerkship years, and 11 articles (22%) did not identify the year involved. The types of learner by year are summarized in Table III. With the 10 quality evaluation studies shown in Appendix B, the split between preclinical and clinical years was fairly even, with two articles in year 1, three in year 2, four in years 3+, and one unspecified. Of the seven evaluation studies that measured student performance, five were for preclinical years (years 1 and 2), one for years 3+, and one unspecified. Three of the five preclinical studies showed improvement in text/exam scores, whereas the one study for year 3+ medical students did not show any improvement in exam scores.

Table III. Types of Learner Reported in the Articles

Type of learner	Authors (see Appendix for details)	Count
Preclinical/basic sciences (year 1)	Baer and Chamberlain, 1998; Broudo, 1999; Davis, 2001; Grundman, 2000; Hodgson, 2001; Magee, 2001; Platt, 1999; Riza, 2001; Schaad, 1999; Srinivasan, 2002	10 (20%)
Preclinical/basic sciences (year 2)	Cameron, 1999; Devitt and Palmer, 1999; Gorby, 2001; Kim, 2001; Mehta, 1998; Parker and Seifter, 2001	6 (12%)
Preclinical/basic sciences (not specified or both)	Bacro, 2000; Bacro, 1997; Dev, 2000; Harris, 2001; Kaelber, 2001; Richardson, 1997; Soula, 2001; Uijdehaage, 2001	8 (16%)
Clinical clerkships (years 3+)	Baker, 2001; Baldwin, 2001; Baumlin, 2000; Devitt and Palmer, 1998; Eysenbach, 1998; Gul, 1999a; Hunter, 2000; Korin, 2001; Mehrabi, 2000; Sarkowski, 2001; Swagerty, 2000; Teague, 2000; White, 2001	13 (26%)
Across years	Chen, 1998; Steinberg, 2002	2 (4%)
Not specified	Dornan, 2001; Gorbis and Hallgren, 1999; Gray, 2000a,b; Gul, 1999b; Hagdrup, 1999; Konstan, 1997; Lehmann, 1999; Locke and Lun, 1998; Martens, 2001; Relan, 2001	11 (22%)

Note. The 10 quality evaluation studies with controlled or pre/postcohort groups are italicized.

e-Learning by Subject Area

The 50 articles covered a wide range of subject areas from basic sciences, clinical clerkships, informatics skills to problem solving. The specific areas reported are anatomy, dermatology, emergency medicine, genomics, geriatric medicine, histology, human behavior and development, infectious disease, medical microbiology, musculo-skeletal system, neoplasia, pharmacology, physical diagnosis, physiology, pathophysiology, surgery, and urinalysis. Some articles covered multiple areas such as medical treatment knowledge, evidence-based medicine, and common medical problems. There is no one subject that predominates. The subject areas reported are listed in Table IV. Of interest is that 3 of the 10 quality evaluation studies involved surgery using synchronous videoconferencing and multimedia self-learning, which were rated favorable by students even though traditionally it has been mostly hands-on teaching.

e-Learning by Learning Activity

Thirty-seven of the 50 articles (74%) reported the use of some type of e-learning technology to enhance individualized learning. Twelve of these articles (24%) included student–student and/or student–tutor interactions through e-mails, bulletin boards, or face-to-face small groups. Five articles (10%) described the use of digital images, simulation cases, animation, and self-assessment, etc. to enhance or replace traditional face-to-face lab classes. The remaining articles covered small group tutorials, classroom lectures, hospital/clinic rounds, and problem-based learning. These findings suggested that the focus of e-learning in undergraduate medical education reported thus far has been on the deployment of online content to enhance

Table IV. Articles Tabulated According to Subject Area Involved

Subject area	Authors (see Appendix for details)	Count
Anatomy	Bacro, 1997, 2000; Devitt and Palmer, 1999	3 (6%)
Common medical problems	Hodgson, 2001; Locke and Lun, 1998	2 (4%)
Dermatology	Eysenbach, 1998	1 (2%)
Emergency medicine	Baumlin, 2000	1 (2%)
Evidence-based Medicine	Gray, 2000a; Srinivasan, 2002	2 (4%)
Genomics	Magee, 2001	1 (2%)
Geriatric medicine	Swagerty, 2000	1 (2%)
Histology	Harris, 2001; Lehmann, 1999	2 (4%)
Human behavior and development	Schaad, 1999	1 (2%)
Infectious disease and medical microbiology	Baer and Chamberlain, 1998; Gorby, 2001	2 (4%)
Informatics skills, computers, and IT	Broudo, 1999; Chen, 1998; Gray, 2000b; Hagdrup, 1999; Platt, 1999	5 (10%)
Medical treatment knowledge	Martens, 2001	1 (2%)
Musculo–skeletal system	Gorbis and Hallgren, 1999	1 (2%)
Neoplasia	Mehta, 1998	1 (2%)
Pharmacology	Konstan, 1997	1 (2%)
Physical diagnosis skills	Grundman, 2000; Kaelber, 2001	2 (4%)
Physiology/pathophysiology	Davis, 2001; Devitt and Palmer, 1999; Parker and Seifter, 2001; Richardson, 1997; Steinberg, 2002;	5 (10%)
Family practice (community, rural, or primary care)	Baker, 2001; Baldwin, 2001; Gray, 2000a; Hunter, 2000; Korin, 2001; Sarkowski, 2001; Teague, 2000	7 (14%)
Surgery	Gul, 1999a,b; Mehrabi, 2000	3 (6%)
Testing and exams	Relan *et al.*, 2001	1 (2%)
Urinalysis	Kim, 2001	1 (2%)
Unspecified or multiple areas	Cameron, 1999; Dev, 2000; Dornan, 2001; Soula, 2001; Uijdehaage, 2001; White, 2001	6 (12%)

Note. The 10 quality evaluation studies with controlled or pre/postcohort groups are italicized.

individualized learning to augment or even replace traditional didactic classroom/lab teaching. There is little on synchronous delivery at the undergraduate program level across multiple sites in real time using such technologies as videoconference or collaborative groupware. The types of learning activity reported in the articles are summarized in Table V.

Use of Videoconferencing

Seven articles from ABI provided product information, innovative approaches, and health related examples on videoconferencing. Currently, the trend is to shift from ISDN- to IP-based conferencing with integrated data, voice, and video using H.323 protocol. IP conferencing in health/medical training is described in five of the articles for surgical training, web-casting of grand rounds, general communication, and medical research meetings. Of interest is the virtual room at Duke University School of Business where a 12-ft video screen is used to portray telepresence with life-size images. The Trans Texas Videoconferencing Network provides an example of a state-wide education infrastructure with over 120 dedicated video sites in 40 Texas cities. A summary of these videoconference related findings is given in Table VI.

Table V. Types of Learning Activity Reported in Articles

Type of activity	Authors (see Appendix for details)	Count
Individualized learning self-study	Bacro, 1997,2000; Baker, 2001; Baumlin, 2000; Davis, 2001; Dev, 2000; Devitt and Palmer 1998, 1999; Eysenbach, 1998; Gray, 2000b; Grundman, 2000; Hodgson, 2001; Kaelber, 2001; Kim, 2001; Konstan, 1997; Locke and Lun, 1998; Magee, 2001; Mehrabi, 2000; Mehta, 1998; Parker and Seifter, 2001; Relan, 2001; Riza, 2001; Sarkowski, 2001; Swagerty, 2000; Uijdehaage, 2001	25 (50%)
Individualized learning student/tutor interactions	Baldwin, 2001; Broudo, 1999; Chen, 1998; Dornan, 2001; Gray, 2000a; Hagdrup, 1999; Hunter, 2000; Korin, 2001; Martens, 2001; Platt, 1999; Teague, 2000; White, 2001	12 (24%)
Laboratory	Harris, 2001; Lehmann, 1999; Richardson, 1997; Soula, 2001; Steinberg, 2002	5 (10%)
Problem-based tutorial	Baer and Chamberlain, 1998; Schaad, 1999; Srinivasan, 2002	3 (6%)
Classroom lecture	Gorby, 2001; Richardson, 1997	2 (4%)
Clinic/hospital rounds	Gul, 1999a,b	2 (4%)
Distributed PBL	Cameron, 1999	1 (2%)

Note. The 10 quality evaluation studies with controlled or pre/postcohort groups are italicized.

Table VI. Summary of Videoconferencing Related Findings

Source	Information
Blank, 1999	Broadcast of minimal invasive surgery over the Adirondack Area network, an IP-based H.320 network system, at Albany Medical Centre
Buyers Guide, 2001	List of conferencing software/hardware vendors including audio conferencing systems, data-conferencing systems, document conferencing, electronic whiteboards, hand-held remote-controls, remote-control systems, videoconferencing systems
Communications News, 2001	IP videoconferencing used at the University of South Florida in its three health science colleges: nursing, medicine, and public health
Espitia and Smith, 2002	Use of videoconferencing and asynchronous computer supported instruction to enhance the veterinary technology program at Palo Alto College in San Antonio, Texas
Hersch, 1999	Use of voice-and-video-over-IP solution over an H.323-based IP network at the University of South Florida's Health Sciences Centre
Merritt, 2002	Live interactions regardless of locations via e-StudioLive Web-casting system for physicians-to-be at the University of North Carolina's School of Medicine
Whiting, 2002	Use of videoconferencing's virtual room at Duke University School of Business
TTVN	Trans Texas Videoconferencing Network, a statewide videoconferencing infrastructure for Texas universities—http://ttvn.tamu.edu

Table VII. Trends and Guidelines on Educational Technology for Medical Schools 1st Part

Source	Information
Anderson, 2000. Association of American Medical Colleges (AAMC)	Results of the 130 survey reports as part of the Medical School Objectives Project (MSOP); parts relevant to educational technology are • 45 of 130 schools require students to have their own computers upon admission to medical schools; others provide computer facilities 24 h a day for students • Some reported significant communication between faculty and students via e-mail • Many faculty have developed software used in their courses Computers used to teach EBM and search literature; importance of library increased • Internet used in self-directed learning and research
Mobert and Whitcomb, 1999. Association of American Medical Colleges (AAMC)	MSOP – Report on use of educational technology by US medical schools in 1998 revealed the following key findings: • Limited progress in accomplishing recommended educational technology goals • Greater use of technology in basic sciences courses than in clinical clerkships • Great variability existed across schools in technology use and its administration • Use of educational technology in medical schools is increasing rapidly • Each school should develop a strategic approach to meet future needs

e-Learning Guidelines and Trends

The Association of American Medical Colleges (AAMC) initiated the Medical School Objectives Project (MSOP) in 1996 to assist medical schools in their efforts to revise their educational programs, improve the quality of medical students' education, and produce physicians who can meet the changing needs of society and of the health-care environment. Of particular interest are that 45 of 130 medical schools require students to have their own computers upon admission, and the need for a strategic approach by each school to adopting educational technology to meet future needs. The World Federation for Medical Education Standing Advisory Committee produced a set of guidelines on use of ICT in medical education that covered a wide range of topics for considerations by medical schools worldwide. These findings are highlighted in Tables VII and VIII.

CONCLUSION

Lessons

The review of e-learning practices for undergraduate medical education provided in this study has led to these observations that are related to our UBC medical school expansion initiative:

Table VIII. Trends and Guidelines on Educational Technology for Medical Schools 2nd Part

Source	Information
Winding, 1998. Copenhagen, Denmark	Guidelines for using computers in medical education, 1998 version on website http://www.med-net.nl/network/conference/1998-1999/lille-maastr-5-1.htm (see WFME, 2001 below for updated version)
Winding, 1998. Copenhagen, Denmark	Guidelines for using computers in medical education, 1998 version presented at Med-Net conference in Maastricht (see WFME, 2001 below)
Winding, 1998. Copenhagen, Denmark	Guidelines on use of computers in medical education, 1998 version from WFME (see WFME, 2001 below)
Winding, 2001. WFME Standing Advisory Committee; World Federation for Medical Education (WFME)	Guidelines on use of ICT in medical education, which cover considerations of • Appropriate use of ICT • Development of online learning materials • Integration of ICT into curriculum • Provision of access to ICT in medical education • Appropriate training and planning the migration from convention learning methods • Finding information on developments in ICT in medical education • Advice on production of electronic learning materials • Recommendations on exchange of educational materials, modules and programs

Synchronous Delivery. Most of the e-learning practices for undergraduate medical education reported in the literature to date are focused on the deployment of interactive content to enhance individualized learning, with little attention to synchronous real-time delivery of basic science lectures, labs, and tutorials. Even though many medical schools have adopted problem-based learning as the foundation of their curriculum, there is still the need for large-group interactions such as plenary lectures and case presentations especially in preclinical years. The question remains as to whether and how ICT can enhance delivery and learning in these large-group settings, such as those for the UBC distributed medical program.

Telehealth Linkage. There is a lack of literature and formal studies on the use and effects of videoconferencing to enhance real-time synchronous delivery of the basic sciences curriculum especially involving multiple sites. With the current trend towards the increased adoption and use of videoconference-based telehealth applications in medical centres and hospitals in Canada, there is a need to explore how to make effective use of existing/emerging telehealth infrastructure and services as part of an undergraduate medical program that is integrated with the clinical setting.

Formal Evaluation. While most of the reviewed articles reported favorable results with the e-learning content and technologies deployed, the lack of methodological details, small sample size and specific technologies involved in these studies have made it difficult to generalize their findings to other settings. As such, it is important for those involved with the design, implementation, and support of e-learning for undergraduate medical programs to demonstrate its cost-effectiveness. This may also be an issue to be addressed as part of the ongoing accreditation of medical

schools to ensure consistent and effective use of ICT that can lead to comparable and successful learning outcomes.

Computer Requirement. About 35% of medical schools in United States require students to have their own computers upon admission. However, it is not clear what percentage refers to laptop computers, which require a different network architecture and support environment than desktop computers. Follow-up studies should be conducted to determine the impact of having a computer or more specifically a laptop as an entrance requirement for undergraduate medical programs in Canada.

Limitations

This initial review of the literature has several shortcomings. First, only PubMed and ABI databases were included using a narrow set of search terms; thus relevant articles elsewhere with different key terms could have been omitted. Second, the search did not include any grey literature or personal contacts, so it is possible for the review to have missed conference presentations, and unreported but highly innovative work that the authors are aware of at certain medical schools. Last, most of the technologies reported are ongoing efforts over time, thus the review is likely out of date since the studies were originally accepted for publication. Our next steps should be to contact selected medical schools in North America and Australia where we are aware of e-learning initiatives at the undergraduate MD program level, and to expand our search to e-learning practices in other disciplines such as the business schools and private sector corporations where communication and training are practised routinely across multiple locations.

APPENDIX A

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APPENDIX B

Author	Study design	Implementation	Results
Baumlin et al. 2000, Ref. ID 98. Mount Sinai School of Medicine, NY, USA	*Objective* – Test hypothesis that computer-assisted instruction (CAI) in emergency medicine (EM) can improve exam scores and course satisfaction. *Design* – Prospective randomized observational cohort study with CAI and no-CAI groups; use of Internet-based EMCyberSchool as part of internship. *Participants* – 4th year medical students in their 4-week block internship rotation in groups of 10–12 students ($N = 112$)	*Topic* – Emergency medicine. *Events* – integration of Internet-based EMCyberSchool into internship; students given unique anonymous access code to track Internet usage and survey response; students surveyed on previous computer experience and their use and opinion of EMCyberSchool; at the end of rotation, students were given a standardized written exam based on the didactic curriculum	• 65% of students wanted CAI as an adjunct to course curricula • Only 28% actually used the tool (77.8% said they did not have enough time to do so) • Students who used the site rated it useful, easy to use, and easy to access • Mean exam score for the students in CAI group was 72.8% versus 68.2% in no-CAI group ($p = 0.058$)
Devitt and Palmer, 1999. University of Adelaide, Australia	*Objective* – Evaluate role of computer-aided learning in a basic science course in the undergraduate medical curriculum. *Design* – Randomized and stratified as 4 groups: didactic, problem solving, free text, and control. All students tested before and after access to the program by multiple choice and modified essay questions. *Participants* – 2nd year medical students ($N = 114$, 90 completed study)	*Topic* – Anatomy and physiology of liver and biliary tree. *Events* – A software (MEDICI) written to allow students to study in three styles; identical, content produced, and matched for each style (problem-based, didactic, and free text response); all students pretested, given 2 weeks of study, then posttested with same questions	• Students with access to material in problem-based and free text response styles did no better in poststudy test than controls • Group studied the didactically presented computer material performed significantly better than other three groups • Three computer groups accessed material with similar frequencies, but free text group spent significantly less time on computer

Grundman *et al.*, 2000. University of Nebraska Medical Center College of Medicine, USA	*Objective* – Test whether a Web-based multimedia program would be more efficient and effective than traditional print-based self-study by medical students. *Design* – Controlled trial, pre and post-test with 20 multiple-choice questions; group A ($N = 60$) used printed manual for ear and multimedia for eye; group B did the reverse ($N = 61$). *Participants* – 1st year medical students ($N = 121$ out of 126)	*Topic* – Physical diagnosis skills related to eye and ear. *Events* – Two courses designed, one about the eye and other about the ear; students could access materials 1 week before posttest; computer logged access and time spent with multimedia material; for print material students had to check in and out of library reference desk with log created; students also kept their own time spent; $25 prize given for top score/group	• Students who used multimedia for the eye or ear course scored higher on posttests than those who used the printed version, when compared using univariate analysis • Students spent more time using multimedia but also improved more, given the time spent
Gul *et al.*, 1999a. Imperial College School of Medicine at St. Mary's, London, UK	*Objective* – Compare surgical teaching via videoconferencing vs. traditional method. *Design* – Students connected by video conferencing compared to those attending operating theatre. Questionnaire on quality of time spent and info obtained by students. *Participants* – Medical students in 1st clinical year with no previous hospital medicine; ($N = 46$)	*Topic* – Surgery e.g., laparoscopic cholecystectomies, hemorrhoidectomies, breast surgery, inguinal hernia repairs. *Events* – Up to 12 students attended videoconference transmitted from theatre using compressed digital video signals; video network is based on 2 Mbit/s virtual circuits with 2-way visual transmission and audio interaction; a moderator would conduct a short lecture prior to operation	• Students gave an overall rating of 9 out of 10 for outpatient teaching using telemedicine compared to 5 for traditional teaching • All students (100%) indicated a willingness to return for telemedicine influenced method of tutoring compared to 65% of students exposed to conventional method • Need further study on objective assessment of knowledge gained by students
Gul *et al.*, 1999b. Imperial College School of Medicine at St. Mary's, London, UK	*Objective* – Compare videoconference from the operating theatre versus traditional method with students in operating room. *Design* – Students selected randomly to participate over 10 weeks; questionnaire used after each teaching session to assess quality of time spent and information obtained by students. *Participants* – Undergraduate clinical students ($N = 40$)	*Topic* – Surgery e.g., basal cell carcinoma, benign naevus, keloid scar, Bowen's and squamous cell carcinoma of skin, sebaceous cyst, lipoma, verruca, inguinal hernia, epigastric hernia, varicose vein, etc. *Events* – Students attended videoconference sessions at the general surgical outpatient dept. in sister hospital 8 km away, using a roll-about system connected by ISDN at 384 kbit/s	• Median score for surgical teaching by videoconferencing was 9.7 out of 10 • All 40 subjects indicated a willingness to return for similar teaching sessions

Appendix (*Continued*)

Author	Study design	Implementation	Results
Kim *et al.*, 2001. University of Washington School of Medicine, USA	*Objective* – Examine students learning before and after revising an educational software program, and patterns of use. *Design* – Two cohorts of students used original version of software; a 3rd cohort used the revised version and compared with 1st cohort based on pre/post test scores and pathway tracking. *Participants* – 466 medical students 2nd yr ($N = 148$ in 1996, $N = 164$ in 1997, $N = 154$ in 1998)	*Topic* – Urinalysis tutor, microscopic interpretation of urinary sediment images. *Events* – 31 concepts of urinary sediment structures & four diseases covered as representative images; software modified after initial use in 1996, 1997 to improve interface design elements, then compared with student use in 1998; also observed four students to learn if they viewed all examples of structures and used visual discrimination features	• Very little difference in the overall performance of the students who used original program and those who used revised program • Navigational data collected in1998 showed that students used an interactive feature for comparing images in different patterns • Demonstrated a potential benefit of linking usage-pattern data and performance
Magee *et al.*, 2001. Washington University School of Medicine, USA	*Objective* – Design a module to teach human genomics and bioinformatics skills. *Design* – Two problem sets were used to teach and evaluate students' proficiency in the human genomics course overall. *Participants* – 1st year medical students in teaching groups of 30 students ($N = 30$)	*Topic* – Genomics. *Events* – Students learned clinical cases and accessed genetic information stored in GenBank, Online Medelian Inheritance in Man and PubMed databases through two problem cases, one as practice and the second for evaluation	• Module was well received by students • Overall, students performed very well on 2nd problem set and successfully passed the human genomics section of the course • Besides increased proficiency at database searching, students were able to integrate material from the molecular genetics section of the course into problem-set answers
Mehrabi *et al.*, 2000. University of Heidelberg, Germany	*Objective* – Development and evaluation of a CBT module in surgery. *Design* – SuperCard used to develop CBT with info on pathogenesis, diagnostic process, X-ray results, surgical techniques, case studies, and questions. Test group used CBT for 90 min. while control group attended lecture; feedback on their experience obtained via survey. *Participants* – 4th yr medical students and nonmedical students ($N = 150$)	*Topic* – Surgical diagnosis for distally fractured radial bone. *Events* – Test group consisted of 4th yr med students ($N = 61$) and nonmedical students ($N = 42$) worked with module for 90 min. then evaluated for experience; control group ($N = 47$) with same background attended 90-min lecture and filled out same survey	• CBT gained in all evaluated criteria (distinctiveness, detailed description, presentation of materials, structure, motivation for learning, time saved learning, and memory retention), 15–20% better scores than lecture • 100% of students found the use of CBT systems useful in student teaching • Most students suggested the use of such programs as a method of exam preparation and self study (90%) or as a supplement to lecture (40%)

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