J Comput High Educ (2008) 20:59–68
DOI 10.1007/s12528-008-9003-2

Mobile devices in health education: current use and practice

Erick Ducut · Paul Fontelo

Published online: 23 October 2008
© Springer Science+Business Media, LLC 2008

Abstract The increasing amount of new scientific information made available by computers and the Internet is demonstrated by the growing number of available health sciences journals. Medical students, nursing students, those in other health science disciplines, and clinicians need to make information more manageable and accessible, especially at the point of care. Technological advances are available to assist them in keeping up with more information than what was accessible to their mentors. In this report, we examine technological advancements and Internet technologies, particularly mobile devices that are currently available to educators and students. We review these advances with respect to how they (a) deliver content, (b) serve different purposes in the classroom and beyond, (c) play different roles in a health sciences student's learning experience, and (d) make available a variety of resources to teachers. These innovations are broadly categorized as mobile technology, Web 2.0 innovations, Learning Management Systems/e-Learning, and medical simulations. Educators and learning institutions must be equipped for the future and maintain proficiency in the ever-expanding world of human medicine by adopting effective strategies that will infuse their lessons with the appropriate technology and allow their students to achieve their maximum potential. Given all these, we believe that the future of the health student and professional will be in mobile computing.

Keywords Mobile technology · Handheld devices · Health education · Web 2.0 technologies · Social networking · e-Learning · Medical informatics

E. Ducut · P. Fontelo (✉)
Lister Hill National Center for Biomedical Communications, National Library of Medicine, 8600 Rockville Pike, Bethesda, MD 20894, USA
e-mail: fontelo@nlm.nih.gov

Introduction

Medicine and the way that it is taught have undergone major changes in the past few years. With the increasingly complex and vast amount of new data available, health sciences students need to know how to access more information than what was available to their mentors. In this era of information overload, health practitioners are expected to learn high-level skills such as accessing, evaluating, analyzing, and synthesizing immense quantities of medical information. Whereas most diseases were treated empirically and symptomatically previously, recent advances are elucidating the pathophysiology of diseases down to the molecular level. To enable doctors and allied professionals to keep pace with the growing amount of new information, new tools are being developed to assist them. Educators also share the challenge of medical education. The teacher's job has become even more complex as they face contradictory expectations in their profession. While students are expected to learn high-level skills, teachers are evaluated by the ability of students to pass tests that may not value these skills (Valdez 2008). Their job requirements continue to shift from imparting skills that will enable students to think critically and solve complex problems across many areas, to teaching isolated skills and information within specialized medical areas. Educators must keep pace with advances in technology and adopt effective strategies to enhance their teaching skills and make their lessons more effective.

Changes in the healthcare system, an effect of rising cost of healthcare and an increasingly aware patient population, has also transformed medical education. Because of increased attention to the problem of medical errors and the need to improve patient safety, testing has become not only routine but also increasingly focused on specialized content knowledge and skills. Past metrics have been questioned and scrutinized, whether they relate to what medical students need to know to succeed in their practice. Sometimes, assessments focus too much on measuring the students' capacity to recall discrete facts at the cost of not properly gauging the students' ability to think critically and solve complex problems. New forms of evaluation have been developed to measure both the knowledge and skills students acquire in medical school and the knowledge and skills needed to succeed in the medical profession. Performance on these high-stake tests is used as a measure of a student's progress and the quality of the medical schools and the teachers who work in them (Honey et al. 2008).

Technology in medical education can assist teachers achieve these expectations and make future health practitioners successful in their field. Various technological advancements are now available to provide tools for both educators and students to use in navigating the growing body of knowledge in the world of medicine. In this paper, we examine these advancements, how they deliver different kinds of content and serve different purposes in the classroom, and how they play different roles in the health science student's learning.

Mobile technology

For more than a decade now, handheld computers or personal digital assistants (PDA) have become standard equipment for medical students and clinicians to get a

handle on the increasingly complex and large amount of information (Embi 2001). For some, this replaced the pocket notebook every student used to carry around. Torre and Wright (2003) wrote that the number of physicians using handheld computers doubled from 1999 to 2003 and predict that most doctors will use handheld computing in a few years. From the introduction of the Apple Newton and Palm Pilot in the 1990s, handheld design and functionality have improved steadily. Current models of handheld devices, including smartphones, are smaller, offer high-resolution screens, are equipped with bigger memories, have longer battery life, and provide a large number of medical applications. Furthermore, handhelds have moved from being a source of static information to a device capable of sharing data to a multitude of users.

The convergence of the processing capability of personal desktop computer and the communication attributes of the mobile phone has created a powerful, Internet-connected, mobile personal device. Most devices available in the market today can wirelessly access the Internet, creating virtual limitless access to medical resources and other forms of information on demand. The release of the new iPhone (http://www.apple.com/iphone/) pushes all these technological advances even further. The current models feature added elements, which include the presence of a built-in accelerometer that responds to motion so that when the display is rotated the accelerometer detects movement and changes the display accordingly. The accelerometer allows the screen to immediately reconfigure and display the entire width of a Web page, view a photo in its proper aspect ratio, or control a game using only the user's movements, much like a game controller. Experts predict that, as several functionalities and innovations like MP3 players, digital cameras and GPS converge into these devices, handhelds and smartphones could overtake the sales of laptops in a few years (Waters 2008). Now, with the emergence of subnotebooks, ultra-mobile personal computers (UMPC), and netbooks, the line between desktops and handhelds are even blurred further.

Ganger and Jackson (2008) reported that medical schools, residency programs, professional organizations, and healthcare systems have realized the potential benefits of these devices and have started to integrate them in the teaching and practice of medicine.

In the classroom, handhelds are used in formal teaching sessions. Through podcasts and videocasts, oftentimes available for download ahead of time, students are able to concentrate on the lecture itself or review the lecture at their own convenience. Notetaking services may not be needed anymore. Handhelds are also used as polling devices to make the discussion more interactive and to assess the students' knowledge of the subject matter in real time. Based on polling data feedback, medical educators can efficiently use limited classroom time by making adjustments to lesson plans and thus focusing on the deficiencies of the students (Kho et al. 2006).

PDAs are also used to evaluate learning experiences inside and outside the classroom. Some schools have shifted from paper to PDA-based evaluations, allowing schools to cut costs but still maintain efficiency. Moreover, PDA-based evaluations are done in real time, hence completion rates are higher and recall bias is avoided (Kho et al. 2006). Students with incomplete requirements may be

reminded electronically via Short Messaging Service (SMS) text messages or e-mail.

In clinical settings, medical students use handhelds as "mobile libraries" to carry medical information wherever they go. In a study by Grasso et al. (2006), they wrote that medical students "considered handheld computing an essential technology that was integral to their performance as future clinicians (p. 201)." Students and residents use handhelds as portable sources of information at the point-of-care to improve patient management and augment learning. Reference tools such as ePocrates Rx and Harrison's Principles of Internal Medicine (a textbook) are among those popular among students and trainees. MedCalc and MedMath applications provide pocket calculators for clinical computations. Other tools have also been developed to provide access to clinical decision support, practice guidelines and physician order sets (Fischer et al. 2003). A survey of Pocketgear (http://www.pocketgear.com/en_US/html/index.jsp) showed that over a thousand applications are presently available. Even before its public release, the Web site "Apple iPhone for Physicians" (http://hlwiki.slais.ubc.ca/index.php?title=Apple_iPhone_for_physicians) report that medical applications have been developed that already uses the new iPhone's features.

For devices with wireless access to the Internet, online medical resources and other forms of information are available. For example, the National Library of Medicine has developed the "PubMed for Handhelds" portal (http://pubmedhh.nlm.nih.gov/nlm/) that provides gateway access to resources to MEDLINE/PubMed, including *ask*MEDLINE and PICO (Patient, Intervention, Comparison, Outcome). These portals are designed as "text-only" especially for small screens and reduced memory capacity of many handhelds. Other services include txt2MEDLINE that provides physicians and healthcare personnel with yet another rapid and convenient method for searching MEDLINE/PubMed through SMS text messaging. Such applications are believed to improve the practice of evidence-based medicine at point of care (Fontelo et al. 2006).

Handhelds are also commonly used by medical students and residents for patient tracking and documentation. Various software applications are available for electronic medical record keeping, physician order entry, clinical notes and prescription writing, and to synchronize handheld information with hospital information systems (Kho et al. 2006).

Text messages can be sent through SMS, and audio, video, and images through Multimedia Messaging Service (MMS). These asynchronous communication channels function under limited telecommunications resources and were useful in the hours and days after the Katrina hurricane in 2005 when regular information dissemination channels were unavailable (FCW Staff 2008; see also Mehta 2008). Mobile phones are increasingly used to disseminate information after Hurricane Katrina and other recent university campus events. Schools, universities, and even the federal sector are tapping on the potential of text messaging to reach their students or members in real time. Many have reported that universities like Penn State, Virginia Tech, and others are presently using text messaging to stay in contact with their students (Briggs 2008; Raboteau 2008).

Handhelds are now transformed into tools for everyday medical practice. Through Web logs, clinical and procedure experience can be documented using handheld devices. Using the compiled data from these documentations, medical educators can then assess a student's training exposure and identify areas of deficiencies (Lee et al. 2002; see also Denton et al. 2003; Ferenchick et al. 2008).

Web 2.0 innovations

Tools, such as blogs, wikis, podcasts, media sharing and other social networking software, are creating virtual learning communities that are not limited by time, space and distance (O'Hear 2008; see also Sandars and Schroter 2007). Mobile technology and Web 2.0 innovations are helping achieve the notion of "anytime, anywhere" learning. Teachers and educators are beginning to explore the potential of Web 2.0 technologies that were once exclusive domains of commerce, media, and businesses. Students' learning is more mobile, often multitasking, and sometimes located at some distance from their parent institution or professional place of practice. Clinical practitioners serving in rural and remote areas no longer feel that they lack proper academic and professional development support because of their geographic isolation from academic centers and medical institutions (Boulos et al. 2006).

Functioning mostly as an online journal, a blog eases online writing and publishing and facilitates critical feedback by allowing readers, teachers and peers, to add their comments and opinions. With mobile blogs, a wider audience can be reached to pose questions, publish work in progress, and provide links and comments on other Web resources. Though most blogs are used as personal online journals, they can also be a collaborative effort that can incorporate different types of opinions that can result in a truly democratic learning environment (Boulos et al. 2006). Numerous medical Web blogs are presently online, examples of which include *Clinical Cases and Images* (http://clinicalcases.blogspot.com/) and the *DIG@UTMB* (http://digutmb.blogspot.com/), the blog of the Dermatology Interest Group at the University of Texas Medical Branch in Galveston, Texas. Some blogs even allow instantaneous posting of high-resolution clinical images taken using a digital camera or mobile phones equipped with cameras. Photos can be annotated by the blogger and are disseminated immediately to a worldwide audience on the Web. Image blogs can potentially be a forum for telemedicine by allowing users to post photos of challenging cases and diagnostic opinions from experts. User verification and authentication requirements may provide some degree of privacy and confidentiality.

Podcasting is gaining popularity among teachers and students as well. Like blogging, podcasts provide educators and students with a wider audience, pushing educational content to learners. Essentially, podcasting is about creating audio or video content for an audience that decides on what they want to listen to, where, when, and how they want to listen to it. At medical schools, like the Harvard Medical School and the Texas Tech University Health Science Center, course lectures are translated into audio and video files that students can download into

their media players. Recordings of lectures can be given to students who are unable to attend the lecture in the classroom. Podcasts allow students to review the lessons while doing something else—commuting to school or walking. Aside from maximizing time for learning, podcasts also provide the versatility of providing lessons asynchronously, eliminating the challenge of gathering students together at one time (Schonfeld 2008; see also Tinkelman 2008). Other medical or health related podcasts include the University of Tennessee Internal Medicine podcast (http://www.utmemphis.libsyn.com/), New England Journal of Medicine podcasts (http://content.nejm.org/misc/podcast.dtl), McGraw Hill's AccessMedicine podcasts (http://books.mcgraw-hill.com/podcast/acm/), and Johns Hopkins Medicine podcasts (http://www.hopkinsmedicine.org/mediaII/podcastsinstructions.html).

More teachers are turning to the Internet for materials for their lectures. De Avila (2008) reports that online video-sharing sites, TeacherTube and SchoolTube, modeled after Google's YouTube, allow educators to share material with other classrooms worldwide. Teachers who access the sites claim that they value the opportunity to see what other educators are doing in their own classrooms and also appreciate the opportunity to "borrow" these videos for their own class. Media-sharing sites like Flickr provide a valuable resource for teachers and students looking for images that they can use in presentations and for other teaching materials (O'Hear 2008).

Popularized by teenagers sharing information with friends online, social networking sites like Facebook (http://www.facebook.com) and MySpace (http://www.myspace.com) have become an Internet phenomenon. In the United States alone, it is estimated that up to 60% of online traffic goes to social networks (Horrigan 2008). Social networking sites provide a forum for discussions and a means to share information and files with users who have the same interests. Mackenzie in 2008 wrote that some social networking sites have even gone a step further through the use of satellite positioning to track users' whereabouts. As expected, they have found their place in the field of education. For example, New Media Medicine (http://newmediamedicine.com) is a social networking site for doctors and medical students that provide e-learning courses, blogs, and discussion boards. Sermo (http://www.sermo.com), launched in 2006, is an online community of doctors that provides a discussion board for physicians to discuss diverse topics involving medical practice. Aside from posting observations and questions about clinical cases, Sermo provides a venue where doctors' opinions can be sought and polled. They can also create online profiles of themselves that will allow them to offer more information about themselves and their practice, network with other doctors, and "rub virtual elbows" with colleagues.

Web 2.0 innovations have clearly found a place in medical education, but there are also cautionary comments raised in some quarters. Critics have warned that emerging tools should first be systematically evaluated to ascertain their benefits and limitations especially in the field of education. More research into the use and evaluation of Web 2.0 tools in medical education may need to be done, because current pedagogic evidence about these innovations in the context of health education is lacking. As Boulos et al. (2006) wrote, "Careful thinking and research are still needed in order to find the best ways to leverage these emerging tools to

boost our teaching and learning productivity, foster better "communities of practice," and support continuing medical education/professional development (CME/CPD) and patient education (p. 6)."

Learning management systems/e-learning

Learning management systems or LMS are software tools designed to manage user-learning interventions. These systems, Blackboard® (http://www.blackboard.com/us/index.bbb), Elluminate® (http://www.elluminate.com), and Interwrite Learning™ (http://www.interwritelearning.com/) offer a wide range of complementary services which encompass provisions for online learning, online assessments, management of continuous education, and collaborative training. Specific components include course calendars, student messaging and notifications, student assessment and testing, transcript and scores display, course evaluations, grading of coursework, and student roster processing. Other resources consist of integration with student performance tracking and planning tools to identify skills and knowledge gaps both in the departmental and individual level. Being Web-based, the system is available anytime and anywhere that there is Internet access; users can view content at their own pace. Discussion forums and live chat rooms provide virtual space for learner interaction with instructors and among other students. Instructors can also hold "virtual office" sessions where they can chat with students and answer questions. With LMS, authors and instructional designers are able to create and manage e-learning content effectively. They can continue redesigning their courses to meet the demands of individual learners and adapt to changing course audiences.

Patient simulations

Although not entirely mobile, patient simulations are gaining use in the academic world through handheld devices. In the past, medical educators and students considered patients as the ideal teacher to master the nuances of medicine. Recently, this traditional approach has somewhat changed. Because of rising healthcare costs, many procedures are done on an outpatient basis. Surgical patients are usually admitted on the day of surgery and are sent home later in the day. At teaching hospitals, this has resulted in fewer patients being available to students. As such, there is no longer time for a medical student to interview and examine the patient, the traditional learning method done since the days of Hippocrates. Outpatient clinics are no different, increased patient load results in decreased time for clinical faculty to teach the students (Issenberg and Scalese 2008; see also Rosenblatt 2008).

Simulations that imitate real-life patients, anatomic regions and clinical tasks have been in use for many years. They range from anatomic models that train in simple tasks to computer-based systems that can mirror clinical situations. At the Carl J. Shapiro Institute for Education and Research at Harvard Medical School and Beth Israel Deaconess Medical Center, for example, medical students are getting

more "patient" time through the Virtual Patient Project. The Virtual Patient Project is a series of approximately 50 "virtual patients," featuring simulations of a full range of common disorders (Rosenblatt 2008). Unlike actual patients, virtual patients provide a uniform learning experience for all students. At their own convenience, medical students can "access" these virtual patients to complement classroom learning and address skill sets necessary to perform medical procedures. Mentors and students can then devote their limited clinic or hospital time to fine tuning patient interaction and bedside skills.

With the increased public attention to problems in medical errors and the need to improve patient safety, medical simulations allow doctors to master the necessary techniques, identify their errors, and learn to correct them without fear of criticism from their mentors or harm to real patients (Issenberg and Scalese 2008). Even video games are being used to improve motor skills essential to performing surgery. Recently, a study by Kahol and Smith (see Kullman) evaluated surgical accuracy of trainee surgeons after playing the Nintendo Wii video game called "Marble Mania." Results showed 48% improvement in their surgical technique for the Wii players compared to the nonplayers (Kullman 2008).

With all the recent technological advances, a diverse range of handheld medical simulators are available that can facilitate learning and evaluation in many areas of medical education. Simulation technology is expected to improve physician training that may translate to improved patient safety and significant healthcare outcomes.

Conclusion

We have provided a brief overview of the various types of technological advancements that are now available and can be used to support and enhance learning. Just as they differ in terms of content, they also differ in terms of purpose that they will eventually serve inside and outside the classroom or laboratory. Each tool will likely play a different role in a student's learning. Educators and learning institutions must be prepared for a technology-rich future and address the ever-expanding world of human medicine by adopting effective strategies that will infuse their lessons with the appropriate technology.

Acknowledgements This research was supported by the Intramural Research Program of the National Institutes of Health (NIH), National Library of Medicine (NLM), and Lister Hill National Center for Biomedical Communications (LHNCBC).

References

Boulos, M. N. K., Maramba, I., & Wheeler, S. (2006). Wikis, blogs and podcasts: A new generation of web-based tools for virtual collaborative clinical practice and education. *BMC Medical Education, 6*(41), 1–8.

Briggs, L. (2008). *Emergency notification: Penn State stays on message*. Retrieved June 9, 2008 from http://campustechnology.com/articles/52868/.

De Avila, J. (2008). *Teachers tap video-sharing in the classroom*. Retrieved June 9, 2008 from http://online.wsj.com/article/SB120649011463564023.html.

Denton, G. D., Williams, R. W., & Pangaro, L. (2003). Core problems reported by students in a palm OS and Internet-based problem entry system predicts performance on the third-year internal medicine clerkship. In *AMIA Annual Symposium Proceedings* (p. 827). Bethesda: AMIA.

Embi, P. J. (2001). Information at hand: Using handheld computers in medicine. *Cleveland Clinical Journal of Medicine, 68*(10), 840–842.

FCW Staff. (2008). *SMS does SOS*. Retrieved June 24, 2008 from http://www.fcw.com/print/12_11/news/92790-1.html.

Ferenchick, G., Fetters, M., & Carse, A. M. (2008). Just in time: Technology to disseminate curriculum and manage educational requirements with mobile technology. *Teaching and Learning in Medicine, 20*(1), 44–52.

Fischer, S., Stewart, T. E., Mehta, S., Wax, R., & Lapinsky, S. E. (2003). Handheld computing in medicine. *Journal of the American Medical Informatics Association, 10*(2), 139–149.

Fontelo, P., Liu, F., Muin, M., Tolentino, H., & Ackerman, M. (2006). Txt2MEDLINE: Text-messaging access to MEDLINE/PubMed. In *AMIA Annual Symposium Proceedings* (pp. 259–263). Bethesda: AMIA.

Ganger, A. C., & Jackson, M. (2008). *Wireless handheld computers in the preclinical undergraduate curriculum*. Retrieved June 9, 2008 from http://www.med-edonline.org/pdf/t0000031.pdf.

Grasso, M. A., Yen, M. J., & Mintz, M. L. (2006). Survey of handheld computing among medical students. *Computer Methods and Programs in Biomedicine, 82*(3), 196–202.

Honey, M., Culp, K. M., & Spielvogel, R. (2008). *Using technology to improve student achievement*. Retrieved June 9, 2008 from http://www.ncrel.org/sdrs/areas/issues/methods/technlgy/te800.htm.

Horrigan, J. (2008). *Pew Internet: Mobile access to data and information*. Retrieved June 16, 2008 from www.pewInternet.org/PPF/r/244/report_display.asp.

Issenberg, S. B., & Scalese, R. J. (2008). Simulation in health care education. *Perspectives in Biological Medicine, 51*, 31–46.

Kho, A., Henderson, L. E., Dressler, D. D., & Kripalani, S. (2006). Use of handheld computers in medical education—A systematic review. *Journal of General Internal Medicine, 21*(5), 531–537.

Kullman, J. (2008). *"Wii" bit of technology aids medical education*. Retrieved June 9, 2008 from http://asunews.asu.edu/20080222_wiistudy.

Lee, J. S., Sineff, S. S., & Summer, W. (2002). Validation of electronic student encounter logs in an emergency medicine clerkship. In *Proceedings of the AMIA Symposium* (pp. 425–429). Bethesda: AMIA.

Mackenzie, I. (2008). *Social networking on the move*. Retrieved June 16, 2008 from http://news.bbc.co.uk/1/hi/technology/6767593.stm.

Mehta, N. (2008). *Op ed: An S.O.S. for SMS*. Retrieved June 24, 2008 from http://www.imediaconnection.com/content/7088.asp.

O'Hear, S. (2008). *e-Learning 2.0: How web technologies are shaping education*. Retrieved June 2, 2008 from http://www.readwriteWeb.com/archives/e-learning_20.php.

Raboteau, A. (2008). *Tech looks to tap into text messaging*. Retrieved June 9, 2008 from http://www.roanoke.com/news/nrv/wb/wb/xp-81392.

Rosenblatt, R. (2008). *Using technology to address change in medical education*. Retrieved June 2, 2008 from http://www.bidmc.harvard.edu/prospective/vol1/ver1/tech_changes.asp.

Sandars, J., & Schroter, S. (2007). Web 2.0 technologies for undergraduate and postgraduate medical education: An online survey. *Postgraduate Medicine Journal, 83*(986), 759–762.

Schonfeld, A. R. (2008). *Podcasts bring medical education to ears of the millennial generation*. Retrieved June 2, 2008 from http://www.acphysci.com/aps/resources/PDFs/Feb_07_Feature.pdf.

Tinkelman, R. (2008). *Podcasting comes to med school curriculum*. Retrieved June 9, 2008 from http://focus.hms.harvard.edu/2006/012706/med_ed.shtml.

Torre, D. M., & Wright, S. M. (2003). Clinical and educational uses of handheld computers. *Southern Medical Journal, 69*, 996–999.

Valdez, G. (2008). *Technology: A catalyst for teaching and learning in the classroom*. Retrieved June 2, 2008 from http://www.ncrel.org/sdrs/areas/issues/methods/technlgy/te600.htm.

Waters, D. (2008). *Why the future is in your hands*. Retrieved June 9, 2008 from http://news.bbc.co.uk/1/hi/technology/7250465.stm.

Author Biographies

Dr. Erick Ducut an otolaryngologist, is currently a post-doctoral fellow in Medical Informatics at the National Library of Medicine, Lister Hill National Center for Biomedical Communication in Bethesda, Maryland.

Dr. Paul Fontelo trained as a pathologist and is presently a Staff Scientist at the National Library of Medicine, Lister Hill National Center for Biomedical Communication.