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USING TECHNOLOGY TO MEET THE CHALLENGES OF MEDICAL EDUCATION

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ABSTRACT

Medical education is rapidly changing, influenced by many factors including the changing health care environment, the changing role of the physician, altered societal expectations, rapidly changing medical science, and the diversity of pedagogical techniques. Changes in societal expectations put patient safety in the forefront, and raises the ethical issues of learning interactions and procedures on live patients, with the long-standing teaching method of "see one, do one, teach one" no longer acceptable. The educational goals of using technology in medical education include facilitating basic knowledge acquisition, improving decision making, enhancement of perceptual variation, improving skill coordination, practicing for rare or critical events, learning team training, and improving psychomotor skills. Different technologies can address these goals.

Technologies such as podcasts and videos with flipped classrooms, mobile devices with apps, video games, simulations (part-time trainers, integrated simulators, virtual reality), and wearable devices (google glass) are some of the techniques available to address the changing educational environment. This article presents how the use of technologies can provide the infrastructure and basis for addressing many of the challenges in providing medical education for the future.

INTRODUCTION

The use of technology in medical education has been developing over many years. The trend in the use of technology has primarily developed in response to the challenges facing medical education. These challenges to medical education are numerous (Table 1). The changing healthcare environment, with the movement of medical care from the traditional hospital setting to ambulatory medicine, has necessitated the ability to provide care in a much shorter period of time and requires changes in documentation with all information, including both health knowledge and medical records, becoming digital. Empha-

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TABLE 1
Challenges of Medical Education

Changing healthcare environment
Changing societal expectations
Patient safety
Ethics — “see one, do one, teach one”
Changing curricular emphasis — competencies and milestones
Explosion of medical knowledge
Need for life-long learning
New generation of learners
Rapidly changing technology

sis on cost-containment and evidence-based use of resources is a national imperative. There are changes in societal expectations so that patient safety is a focus at all levels of medical education. This has also raised the ethical issues of learning interactions and procedures on live patients, with the long-standing teaching method of “see one, do one, teach one” no longer being acceptable.

There is also the change in curricular emphasis, both in undergraduate and post-graduate training, from simple knowledge acquisition to the need to demonstrate competencies in the learner (1). The explosion of medical knowledge no longer allows physicians to keep in their mind all knowledge that is necessary to provide quality patient care. It is estimated that more than 600,000 articles are published in biomedical literature every year. If a student attempted to keep up with the literature by reading 2 articles per day, in 1 year this conscientious individual would be more than 800 years behind (2). Although the profession has long held that physicians need to be life-long learners, this concept is now an imperative. There is also a new generation of learners; “digital natives,” a phrase termed by Prensky (3). These are young people born into the digital world who speak the language of technology fluently. They expect their education to reflect their expertise in different levels of technology integration and are accustomed to technology-enhanced learning environments. Finally, medicine is experiencing a rapidly changing use of technology in the delivery of care.

The educational goals of using technology in medical education include facilitating basic knowledge acquisition, improving decision making, enhancement of perceptual variation, improving skill coordination, practicing for rare or critical events, learning team training, and improving psychomotor skills. Different technologies can address these goals. The task of medical educators is to use these new technologies effectively to transform learning into a more collaborative, personalized, and empowering experience. Bonk captures the essence of this new age of technology tools for education by stating “Anyone can learn anything from anyone at any time” (4).

TECHNOLOGY AND MEDICAL EDUCATION

There are many technologies currently being used in medical education. Although the following attempts to present these as individual approaches, the applications overlap in terms of technological components and instructional possibilities.

Computer-assisted Learning

Education of undergraduate medical students can be enhanced through the use of computer-assisted learning. One example is the use of “flipped classrooms” in which students review an online lecture before the lecture session, and come to the classroom to have an interactive session with the teacher. This time can now be spent on further exploring complex issues or discussing and solving questions in a more personalized guidance and interaction with students, instead of lecturing. Research in this area has not been extensive. Although randomized trials in education suffer due to difficulty with standardization, contamination between two arms, inability to blind the participants, and difficulty measuring outcomes, a few randomized trials have been conducted asking outcome questions about flipped classrooms with some success (5, 6). These studies showed a positive effect in the areas of student involvement, satisfaction, and knowledge acquisition. Bridge et al conducted a 5-year retrospective study of streaming video use at Wayne State University School of Medicine and found the student response to be overwhelmingly positive, with just a small percentage of students reporting that they rarely or never used streaming video of lectures (6).

Mobile Devices

Personal digital assistants (PDAs) are routinely used by students for medical questions, patient management, and treatment decisions. Medical apps for iPhones and Android devices are numerous. Although many focus on anatomy and physiology, some address medical problem solving, diagnosis, and treatment. The website iMedicalApps.com (7) provides recommendations for the best apps for students and residents and links to online app stores for purchases. Stanford University, as one example, has a “Student App” webpage and Stanford apps that can be obtained from the Apple store. Many medical apps are also available to be used on tablets as well as phones.

Digital Games

The application of digital games for training medical professionals is on the rise. The so-called "serious" games provide training tools that provide challenging stimulating environments, and are often used for training for future surgeons (8, 9, 10). Use of serious games for surgical training improves eye-hand coordination and reflex times (10). At Florida State University College of Medicine, students in geriatric clerkships play ElderQuest, a role playing game in which players work to locate the Gray Sage, a powerful wizard in poor health that each player must nurse back to health (11). One published assessment of this tool was used to teach geriatric house calls to medical students. The investigators found that this method provided medical students with a fun and structured experience that had an effect not only on their learning, but also on their understanding of the particular needs of the elderly population (12).

Simulation

The aim of simulation is to imitate real patients, anatomic regions, or clinical tasks, and/or mirror the real-life circumstances in which medical services are rendered. Simulations can fulfill a number of educational goals (Table 2). A qualitative, systematic review by Issenberg et al, spanning 34 years and 670 peer-reviewed journal articles, found that the weight of the best available evidence suggests that high-fidelity medical simulations facilitate learning under the right conditions (13). The learning characteristics identified included providing feedback, repetitive practice, curriculum integrations, range of difficulty levels, multiple learning strategies, capture of clinical variation, individual learning, and the ability to define outcomes or benchmarks. Issenberg et al concluded that although research in this field needs improvement in terms of rigor and quality, high-

TABLE 2
Education Goals for Simulation

Provides effective feedback
Repetitive practice
Range of difficulties
Multiple learning strategies
Capture clinical variation
Controlled learning environment
Individualized learning/mastery and team training
Defined outcomes and benchmarks
Effective method for team training
Simulator validity

fidelity medical simulations are educationally effective and simulation-based education complements medical education in patient care settings (13). Bradley has published a review on the history of simulation and Lane et al, a comprehensive review of simulation in medical education (14, 15).

The use of simulation spans a spectrum of sophistication, from the simple reproduction of isolated body parts through to complex human interactions portrayed by simulated patients or high-fidelity human patient simulators replicating whole body appearance and variable physiological parameters (14,15). One of the earliest simulators, a mannequin named Rescusi Anne, was developed 35 years ago when mouth-to-mouth resuscitation protocols were introduced (16). About the same time, Harvey, a simulator to teach cardiac examination skills, was developed and is still used worldwide in medical schools and hospitals (17).

Part-task trainers consist of 3-D representations of body parts/regions with functional anatomy for teaching and evaluating procedural or psychomotor skills, such as plastic arms for venipuncture or suturing. Palp-Sim (18) is an example of a program that uses a haptic system which provides simulation for placing a cannula in the femoral artery. Haptic systems refer to those simulators that replicate the kinesthetic and tactile perception and produce a feeling of resistance when using instruments within a simulated environment (14, 19, 20).

Integrated simulators combine a mannequin (usually a whole body) with sophisticated computer controls that can be manipulated to provide various physiological parameter outputs that can be physical (such as a pulse rate or respiratory movements) or electrical (presented as monitor readouts). These simulators are often used as the core platforms of simulation centers. Simulation centers attempt to replicate fully functioning operating rooms, intensive care units, emergency departments, or patient rooms (15). A well-structured case in the simulation center can teach and assess many, if not all, of the patient and process-centered skills, as well as team involvement and management.

Virtual Reality (VR) simulation refers to the recreation of environments or objects as a complex, computer-generated image. In VR simulations, the computer display simulates the physical world and user interactions are with the computer within that simulated (virtual) world. There are a number of VR programs used in medical education. One example, MIST VR (Minimally Invasive Surgery Trainer–Virtual Reality), has been specifically designed to provide trainees with a realistic and assessable environment for developing skills, particularly in the area of laparoscopy (21, 22).

The LINDSAY Virtual Human Project, a computer-generated 3-D anatomy and physiology model, permits the user to visualize anatomy and other human components in a 3-D simulation using 2-D computer interfaces, including mobile devices, and provides an immersive approach to anatomy and physiology (23, 24). Use of anatomy simulation models have not been well studied although computer-generated 3-D models to teach anatomy have proliferated. One randomized study by Nicholson did show that the 3-D computer-based anatomical model enhanced students' learning of anatomy of the ear (25).

Second Life is an online virtual world, developed by Linden Lab (a company based in San Francisco, CA) and launched on June 23, 2003, as of 2014 has approximately 1 million regular users. Within any Second Life simulated environment, users exist through avatars which interact realistically with other avatars online. Islands or areas of learning can be established where avatars can visit, interact with other avatars, and also interact with information provided by institutions such as the CDC, NLM, PubMed, and medical schools to mention a few (26). Second Life currently features a number of medical and health education projects (27, 28) and educators are in the process of evaluating the value of Second Life in different aspects of medical education (26, 29, 30).

Wearable Technologies

Google Glass is being tested as a new layer of technology that makes education more realistic and potentially more effective. At the University of California, San Francisco (UCSF) School of Medicine, a cardiothoracic surgeon, Pierre Theodore, MD, has used Glass in more than 20 surgeries. He uses Google Glass to project radiologic images (CTs, MRIs, etc) into the field of vision as he operates to assist in cases where he can use additional clinical data to help guide activity (31).

The role of Google Glass and other devices will become commonplace across the healthcare continuum and provide an essential clinical tool, from use by the paramedic on location to advanced care and consultations (32). The University of California, Irvine School of Medicine may be the first to integrate Google Glass into the curriculum (33). Educators believe that students will benefit from Glass's unique ability to display information in a smartphone-like, hands-free format, being able to communicate with the internet via voice commands and being able to securely broadcast and record patient care and student training activities using proprietary software compliant with the 1996 federal Health Insurance Portability & Accountability Act (31).

DISCUSSION

Medical education is rapidly changing, influenced by many factors including the changing healthcare environment, the changing role of the physician, altered societal expectations, rapidly changing medical science, and the diversity of pedagogical techniques. Societal influences and the changing healthcare environment are influenced by the internet, globalization, cost containment, aging of society, increasing public accountability, a medically informed public, demands of personalized care, population diversity, expansion of healthcare delivery by non-physicians, and changing boundaries between health and healthcare. Physicians now work in teams, are salaried, part of a complex organization, and must be highly accountable. Challenges of preparing the future doctor involve emphasis and standardization of competencies and learning outcomes, integration of formal knowledge and clinical experience, patient-centered care, population health, cost-conscious−high value care, and understanding the organization of health services.

Use of technologies for undergraduate, postgraduate, and continuing medical education has become increasingly prevalent. There are a number of educational advantages that are listed in Table 3. These modalities facilitate knowledge acquisition, improve decision making, enhance perceptual variation, improve skill coordination, and provide an educational environment that engages the learner and allows learning that does not endanger the patient. Use of computer technologies has the additional benefit of being able to assess competencies and milestones, and provide the student, at any level, with the tools to continue to access the medical knowledge necessary to deliver quality care and be a life-long learner.

TABLE 3
Educational Advantages of Technology

Safe, controlled environments that eliminate risk to patients
Enhanced, realistic visualization
Authentic contexts for learning and assessment
Documentation of learner behavior and outcomes
Instruction tailored to individual or group needs
Learner control of the educational experience
Repetition and deliberate practice
Enhance perceptual variation and improve skill coordination
Standardization of instruction and assessment

The use of technology in medical education should be to support learning; it should not be a replacement for face-to-face learning. Educators must still focus on the principals of teaching, not on the specific technologies. Technologies are just one tool in the educational toolbox. The task of medical educators is to use these new technologies effectively to transform learning into a more collaborative, personalized, and empowering experience. To paraphrase Confucius: “Tell me and I will forget, show me and I may remember, involve me and I will understand” (34).

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DISCUSSION

Weinberger, Philadelphia: One of the things with education is the whole regulatory environment surrounding it; the LCME for medical schools, ACGME for graduate medical education, and so forth. Have they taken a stand in terms of promoting or restricting — obviously you are talking about changing a lot in the educational environment — and I am wondering what the regulatory bodies are doing in terms of incorporating this new type of technology?

Guze, Riverside: The accrediting bodies are very conservative. However, what they overwhelmingly use as outcomes are usually things like test exams. They also use student satisfaction, because they use student surveys. So far their silence has been basically that if you get to the end and can demonstrate competence in whatever you do then they have been accepting of it.

Zeidel, Boston: We have actually developed at our place simulations for physiology which make the physiology dynamic rather than static. Of course, this seems like a great idea. I would urge that as we apply these technologies that we actually develop the ability to test whether they work. There is an awful lot that has gone on in education since Flexner, actually where we change the way we educate, and we don't measure whether it makes any difference. All of us who have lived in suburbs have recognized that every 5 years there is a new math curriculum. We have no idea whether it is any better than the old math curriculum, but everyone has to learn it. I would urge that we try with the developing field of measuring efficacy in educational interventions to measure whether these things improve things or not, so that we can try to be a bit rigorous about what we are doing. Of course, all the medical schools in the country are probably going to flip their curriculum in the next several years, and probably I fear there will be no effort to figure out if it is any better than what we were doing before.

Guze, Riverside: It's a very good point. Fortunately or unfortunately, in this area the major research is really qualitative research and not quantitative research. There have been a few studies that have looked at exam rates and shown that students who are more actively involved, through using some simulation technologies, have done better.

Katz, Boston: My comment has to do with ultimately the binary characteristics of technology, which is, there is a right answer and there is a wrong answer in general. Just this week, I heard that there were complaints about our otherwise very good co-training simulation session. That there was sort of always a right answer, but they rarely got beyond that. They very rarely got into the variability of the real situations. It gets to this issue of sort of ambiguity; the value of being able to hold multiple right answers at the same time without an exact correct answer. That's one of my concerns about some of this technology. Although I readily acknowledge the many, many advantages. I was wondering if you could talk about that. How does this affect the learners ability to be open minded in a situation where there is often time a right or wrong answer?

Guze, Riverside: I don't think this is a substitute for a certain amount of face-to-face interaction that has to go on. There is the art of medicine that we can't ever, from my perspective, leave behind. These are tools that actually get a student, I believe, more actively involved. But without the modeling I think by the physicians who apply the art and are able to say, “This may be right in this individual but may not be right in others,” we then would be missing an important component of education. I think what the technology does is take advantage of the fact that as adults we do much better if we are actively involved in doing something.

Bradsher, Little Rock: When my son graduated from medical school a few years ago, he was distraught that his intern coat wouldn’t fit his IPad, so my communal wife, who is home economics major, took one of my coats and harvested a pocket and put inside his coat an iPad pocket. He showed it to his intern mates who said, “You are such a nerd.” Then about 20 minutes later they said, “Can we get one of those?”