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Critical Topics in an Aging Society

Using Technology to Improve Care of Older Adults

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Advances in Health Education Technology

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The passing of knowledge from one to another is a practice as old as time. For millennia, educated scholars have communicated their knowledge to students. While this transmission of information is not new, the mechanisms by which this information is transferred have changed drastically. Rapid advances in immersive technologies like virtual reality (VR), or augmented reality (AR), are beginning to transform experiential learning in ways that allow for failure without risking patient safety. From online digital classrooms to mobile applications and smartphones, technology is changing how health education is being delivered to both clinical professionals and patients.

In the context of health education, the process of learning involves practice, observation, modeling, peer support, and didactic experiences. One of the cornerstones of clinical professional education is experiential learning through practical experience. For example, medical, nursing, pharmacy, and dietary professions each require clinical practice as part of their curricula. Learning through practice allows students to attempt tasks to refine their execution, solidify comprehension, and reduce fear when attempting newly acquired or unfamiliar skills. However, this model can pose some risk for patients when applied in a clinical setting. Attempting complex procedures on living patients can be daunting, with the margin of error small. Traditionally, health education programs have focused on classroom, patient teaching, and clinical experiences to educate professionals and patients alike.

Patients also learn through practice. For example, self-care activities such as self-catheterization, insulin injection, or ostomy care are often foreign and uncomfortable, yet these skills are necessary to maintain health or manage chronic illnesses. Health education technologies represent opportunities to teach these skills in a risk-free environment, thereby reducing or eliminating patient fears when learning unfamiliar tasks.

Health education technology has advanced from basic informational websites to fully immersive interactive systems which can now provide dynamic learning experiences, social interactivity, and realistic, automated scenarios that mimic clinical events with live patients. These improvements can be attributed to increased processing power of computing tools, proliferation of high-speed Internet connectivity, and innovative new tools such as VR devices. According to Thibault (2015), when technology is used correctly in health education, it facilitates learning while freeing the learner to engage in teamwork and patient-care skill mastery. In this chapter, we explore why technology is needed in health education, review examples of different types of technology in use today, and examine how these tools may be used to support training of clinical professionals as well as educating patients.

WHY IS HEALTH TECHNOLOGY NEEDED?

There are many factors influencing the need for technology-supported education. For example, many clinical professions like pharmacy (Patry & Eiland, 2007), nursing (American Association of Colleges of Nursing, 2015), and medicine and allied health (Moskowitz, 2007) are suffering from clinical faculty shortages, making it difficult to enroll students in these programs. While the reasons for these shortages are varied, they are not the focus of this chapter. Nevertheless, these shortages have motivated educational institutions to find ways to deliver clinical professional education in the most efficient way possible.

Furthermore, the clinical workforce is changing. Younger professionals seeking education and entering the workforce have grown up with technology at the center of their lives. These generational differences mean that digital native learners place a higher emphasis on technology, and are more comfortable using it (Reynolds, 2013; Satterfield, 2015). They expect cutting-edge educational programs to include innovative technologies.

The environment in health care has also become increasingly technical. Medical devices, computerized charting, at-home monitoring, and other tools are changing how professionals deliver care to patients. Clinical professionals entering the workforce need to be prepared to operate, understand, and interact with highly complex digital systems in order to provide care. As more care is being shifted outside of the hospital setting, technology is needed to support patient self-monitoring and management. In-hospital educational systems begin teaching patients from the moment they are admitted and, in some instances, can include ongoing monitoring and technology-mediated educational support once discharged. For example, transitional care programs that focus on preventing readmissions postdischarge often include self-monitoring technologies and educational tools using wearable or connected devices, videoconferencing, and tablet computers.

EXAMPLES OF TECHNOLOGY IN HEALTH EDUCATION

Learning Management Systems

The ability to efficiently share information is a critical component to the prosperity of any health care organization. An important component to this success is having an effective infrastructure for learning to facilitate patient empowerment, provider competence, and career development. Furthermore, there are also mandated requirements for the appropriate delivery, documentation, and tracking of specific types of educational material ranging from professional medical licensing to government-compliance training and patient-informed consent. Managing these course records can be a significant administrative burden and risk, if done manually. Therefore, efficient scalable electronic solutions for education management have become a key strategic initiative for numerous health care organizations. More specifically, e-learning provides opportunities uniquely suited to address the concerns of geriatrics educators, such as the trend to move teaching venues to decentralized community settings, competency-based education requirements, and the need to train at a time when geriatric health care professionals have limited time available to share knowledge (Ruiz, Teasdale, Hajjar, Shaughnessy, & Mintzer, 2007).

Many people in health care perceive e-learning as a complement to traditional forms of medical education (Cook et al., 2008; Ruiz, Mintzer, & Leipzig, 2006). However, research suggests that the effectiveness of computer-based teaching is at least equivalent to lecture-based medical education (Davis et al., 2007). Furthermore, recent research suggests that an electronic-based informed consent may actually improve patient understanding compared to paper-based consent processes (Rothwell et al., 2014).

There are a variety of electronic solutions available to meet an organization's educational needs. Some institutions have decided to utilize a mix of existing applications typically intended for other purposes, such as email, desktop folders, online meeting tools, and spreadsheet software. However, the lack of interoperability and automation with this type of strategy results in the need for dedicated resources to manually upload and track information, which quickly becomes an unmanageable burden for even small organizations. As a result, an entire industry of dedicated software applications has emerged for e-learning. One of the most common tools used in e-learning today is the learning management system (LMS; García-Peñalvo & Alier Forment, 2014).

What Is an LMS?

An LMS is a centralized software infrastructure that delivers and manages training and learning modules. Part of this management involves handling the registration, scheduling, and tracking of electronic classes in an automated or semiautomated way. With an LMS, course test questions can be integrated into modules and automatically documented to meet the continuing education requirements of accreditation boards. Most LMSs also have an analytics component that can provide insight into the performance of an individual, group, or even the course itself (Abdullateef, Elias, Mohamed, Zaidan, & Zaidan, 2016).

Advantages of an LMS

The automated features of an LMS provide scalable efficiencies and advantages compared to traditional educational management workflows. This is relevant for any industry, but is particularly significant in health care owing to the high volume of training and compliance requirements. The ability to efficiently track governmentally mandated health care–compliance requirements is an important feature of an LMS. In a typical LMS, courses may be available for self-registration or may be prescheduled for individual, group, or subgroup delivery. Alert thresholds can be adjusted to remind learners or managers about overdue modules, and certificates can be automatically issued after the satisfactory completion of training. Importantly, the on-demand availability and self-guided services of the web-based courses made available through an LMS add convenience to the busy schedules of medical professionals. Most LMSs provide learners and administrators with custom dashboards that arrange relevant content by requirements, topics, or subjects. Some dashboards may also have integrated calendars and timelines to further enhance the user experience. Ideally, entering a new hire's information into the system will automatically trigger a set of training modules to be delivered to an individual that is specific to the individual's role within the company. Web-based learning has been shown to be an effective method of training medical professionals regardless of their age, education, or prior computer experience; an LMS provides the infrastructure for efficient delivery of e-learning to an entire organization (Atreja et al., 2008; Ellis, 2009).

Available LMS Options

Although the LMS market is relatively new, there are currently hundreds of LMSs available to choose from. Deciding on the most appropriate and cost-effective solution for the specific needs of a health care organization depends on understanding the institutional goals, available resources, and target audience(s). In general, user experience and reliability of a product are typically among the most important factors (Zaharias & Pappas, 2016). The following are additional options to consider from the perspectives of several different key stakeholders.

From a learner's perspective, the ability to provide feedback about a course or software has been correlated with improved outcomes in health education (Cook, Levinson, et al., 2010). There are some LMSs that have more advanced collaborative functionalities that provide platforms for online interaction with course creators, coaches, and learners. Regardless of the content and delivery method, an optional single-sign-on (SSO) feature that integrates with existing security credentials eliminates the need for additional login prompts, or the need for an employee to remember a different set of passwords and user names. Being able to access content on mobile devices is an additional convenience for learners, but not currently available with many LMSs (Dahlstrom, Brooks, & Bichsel, 2014).

It is important to find an LMS solution that matches the needs and technical abilities of the expected course creators at an institution. Many traditional LMSs require educational material to be incorporated from different software, such as videos or slide presentations. It is, therefore, critical to confirm that the components to be utilized are compatible and that the process of creating a course is streamlined to promote efficiency and user adoption. However, there is a growing trend for systems to provide authoring tools and templates that allow the creation and modification of content completely within the same LMS solution. Some LMS vendors also have premade content in their database that may be available to satisfy specific requirements. The ability to integrate course material from third-party courseware is also an important factor that can significantly decrease the burden of creating specific, mandated courses.

For marketing and sales, the ability to integrate an LMS within a corporate website may be particularly important if there is a desire to connect with patients and nonemployee partners. Furthermore, making valuable educational content available on an external website can promote an organization's brand equity, or be combined with an e-commerce module to create an additional revenue stream. The additional web traffic to the LMS component of a corporate website is also expected to increase the search engine optimization (SEO) ranking of that website. However, the ability to integrate with an external website platform is not available with many LMSs. Branding the LMS vendor solution to appear as an integrated part of the electronic health care platform is an additional optional feature with variable penetrance in the LMS market.

The majority of the previously mentioned features are important for consideration by technical and support staff who are typically also charged with the task of implementation, integration, configuration, and disaster recovery planning of an LMS, as well as initial training of the end users (Ellis & Calvo, 2007). The ability to effectively establish and manage the user permissions and security of the LMS are also important technical factors.

Additional technical considerations include the foundational infrastructure of the solution. For example, LMSs may be installed on in-house servers (on premises), or may be accessible through remote vendor servers as a Cloud "Software as a Service" (SAAS) solution. In general, an SAAS solution is a less expensive option, in part because implementation, maintenance, and information technology (IT) support are typically provided externally by the vendor. However, an on-premises LMS is generally more customizable, and may, therefore, be easier to integrate with other locally hosted software products. A third-party maintenance model takes elements of both options: the software is installed on-premises but the maintenance and upgrades are managed by the LMS vendor (Ellis, 2009).

If there is a desire to incorporate video content into educational courses, there are additional technical considerations. Video can be obtained from a variety of sources ranging from smartphones, online meeting tools, and dedicated software. Specific software can be used to record computer screens with audio narration (often referred to as *screencasts* or *video screen capture*). Screencasts can be an effective and efficient way to train employees on the use of specific desktop software, onboarding, and career development. However, regardless of the video solution utilized, it is important to ensure that the content can be efficiently managed and the specific video format can be integrated with the LMS vendor solution being utilized.

An LMS has the potential to efficiently deliver a variety of critical health care educational material to a wide range of consumers. Therefore, from a leadership and management perspective, it is critical to establish a centralized strategy and organized plan for success. The different needs and insights of individuals and departments must be fully understood to prevent the formation of a disconnected and fractured platform that is difficult to navigate and maintain. Dedicated requirement gathering will help to inform an organized project and governance plan to account for the specific perspectives of expected stakeholders such as clinical, legal, compliance, and human resource (HR) departments.

Augmented Reality and Virtual Reality

Virtual and augmented realities have moved from the gaming world into health and medical education. In VR, the user experiences a completely computer-simulated environment. Most video games utilize elements of VR technology. By contrast, AR allows users to interact live with technology-enhanced versions of reality, which have been married with digital media, imposing objects into the real world. Both can engage multiple senses and include sound, digital video, or graphics, as well as engaging the sense of touch through haptic response.

Experimentation with primitive versions of VR began in the first half of the 20th century through three-dimensional (3D) imagery and video, early flight simulators, and primitive headset displays. The term *virtual reality* was coined in the 1980s by researcher Jaron Lanier, who went on to develop early versions of VR head-mounted displays, goggles, and gloves, according to the Virtual Reality Society (2016). In addition, over the past 30 years, true AR has also made its way into mainstream culture, from virtual lines marking first downs during live NFL games, to interactive displays used by soldiers and astronauts.

User interaction with modern VR and AR occurs through a variety of modalities. VR products, having been in the marketplace for over 30 years, offer a wider variety of options. Head-mounted displays with 3D controllers, such as the Oculus Rift (2016) or the HTC Vive, or cell phone–based viewers, such as the Samsung Gear VR, are newer and provide a more immersive experience. Video gaming systems create virtual worlds through digital media, sound, and haptic feedback. Numerous products are scaled, or created for, smaller screens of smartphones and tablets for greater reach, access, and portability.

AR products for the consumer are relatively new to the marketplace. Products such as Microsoft HoloLens glasses (Microsoft Corporation, 2016) project holographic images, overlaying the real world, allowing users to interact with both at the same time. Also, in 2016, smartphones and tablets have joined the AR world. Pokémon GO, which became wildly popular in mid-2016, but not originally intended for this purpose, is an example of how AR could improve health, in this case, by increasing physical activity. Utilizing a mobile phone's global positioning system (GPS) and camera functionality, users of Pokémon GO must move about to capture and interact with digital creatures.

One area in which AR has great potential for broad commercial success is remote training on medical devices. For example, researchers at University of California, San Diego (UCSD), are studying innovative uses of VR (Oh et al., 2016). They have built a prototype of a remote training system for a wound care device, the WoundVac. The instructor uses a VR setup, in our case an HTC Vive system, to see what the student can see, who has a real WoundVac system they are learning how to use. To allow the instructor to help the student use the WoundVac, the student can see the instructor's hands, as well as 3D annotations, through a HoloLens. The two systems are connected over the regular Internet—no dedicated network connection is required. The system allows the training on complex medical devices much like when instructor and student are in the same location. This can allow experienced instructors to give one-on-one training to many more students than they could if they were to physically travel to each student's location. Figure 13.1 illustrates the concept of how the student can see the instructor's hands, as well as a virtual copy of the main WoundVac unit which the instructor moved to a new location to make room for connecting the vacuum hose to it.

Over the past few years, the uses of AR and VR have found success in health care applications, both in training health care professionals and imparting or improving patient skills. Through both media, patients and students alike can experience situations, providing for desensitization or practice with varying behaviors in a safe environment (García-Betances, Fico, Salvi, Ottaviano, & Arredondo, 2015).

Explosive growth is expected with AR taking a great role according to the Virtual Reality Society (2016). An international organization, the VR/AR Association, has been created "to foster collaboration between innovative companies and people in the virtual reality and augmented reality ecosystem that accelerates growth, fosters research and education, helps develop

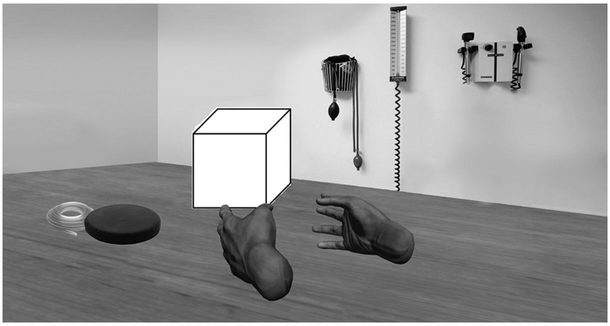

FIGURE 13.1 Wound vacuum (represented as white box) as seen by student, with instructor's virtual hand.

industry standards, connects member organizations and promotes the services of member companies" (VR/AR Association, 2016), including a committee wholly focused on digital health, medical education, health care, and education.

VR/AR in Health Professional Education

Medical applications allow for skill building in fields ranging from virtual surgery and dentistry training, to in-field assistance devices for phlebotomy, such as illuminating vein maps on skin surface. Ferguson, Davidson, Scott, Jackson, and Hickman (2015) examined the opportunities AR and VR bring to nursing education and training, such as virtual classrooms or video game training, and recommended these be integrated as teaching and learning strategies. Given the pervasiveness of smartphones, integration of VR/AR in provider training is almost a necessity to disseminate low-cost health care solutions (Ferguson et al., 2015; García-Betances et al., 2015). Mobility of phones allows the classroom to go with the student (or patient; McMahon, Cihak, Gibbons, Fussell, & Mathison, 2013).

In dietetics education, several VR simulation platforms are being utilized, which focus on skill building from nutrition evaluation, patient interactions (interviewing and counseling), to nutrition support. Not only do these methods exercise critical thinking skills and problem solving in the student, they also serve as evaluation of student progress and readiness (Camacho, 2014; Davis, 2015).

VR/AR in Patient Education

Patient care and treatment options in VR and AR are ubiquitous, with existing solutions aimed at improving, enhancing, or even replacing traditional therapies and text-heavy patient education. VR affords users the ability to develop and practice self-regulation skills necessary for success in managing health conditions, ultimately improving adherence, and provide ongoing support (Coons, Roehrig, & Spring, 2011). Examples are in ophthalmology using 3D digital education, mental health by promoting relaxation and meditation, and nutrition by promoting weight loss and healthy food choices. Recent data suggest that these tools are effective at improving patient behaviors. To illustrate, researchers found a VR-based weight loss intervention to be as effective in producing weight change as face-to-face intervention, and more effective in improving indicators of behavior change and self-efficacy (Behm-Morawitz, Lewallen, & Choi, 2016; Johnston, Massey, & DeVaneaux, 2012). In children, multiple health behavior changes were realized using virtual pets to increase physical activity and fruit and vegetable intake (Ahn, Johnsen, Moore, & Ball, 2016; Ahn, Johnsen, Robertson, & Basu, 2015).

An AR mobile intervention was developed by a Mexican research group to reduce sugar intake, and combat common challenges in understanding food labels for highly processed, sweetened beverages (Escárcega-Centeno, Hérnandez-Briones, Ochoa-Ortiz, & Gutiérrez-Gómez, 2015). Use of VR avatars showing weight gain related to soda consumption allowed users to experience effects virtually, positively altered user perception and soft drink consumption, and was more successful than traditional educational handouts (Ahn, 2016).

García-Betances, Jiménez-Mixco, Arredondo, and Cabrera-Umpiérrez (2014) recognized VR and AR therapies as game changers in the field of dementia. Several studies showed significant improvements in poststroke and Alzheimer's dementia patients (gait, balance, and motor function) with a variety of VR interventions, varying from custom design to commercially available, such as Wii-Fit, when compared to traditional therapies (Allain et al., 2014; Imam & Jarus, 2014; Luque-Moreno et al., 2015; Padala et al., 2012; Tsoupikova et al., 2015). Fully immersive 3D therapies hold advantages over 2D environments given the increased sensory resources required (S. M. Slobounov, Ray, Johnson, E. Slobounov, & Newell, 2015). Other medical interventions identified as successfully benefiting from VR/AR exposure include pain mitigation (Trost & Parsons, 2014), and teaching food allergy management to individuals with intellectual disabilities (McMahon et al., 2013).

While research supports the use of VR and AR in various settings, there are challenges. The upfront development costs can be high in custom implementations. Furthermore, there is concern that fully immersive technologies may deliver an overwhelming amount of information to the user, rendering them less effective. Finally, some individuals may be susceptible to cyber sickness, similar to motion sickness, and unable to benefit (Keshavarz, Riecke, Hettinger, & Campos, 2015).

The potential for AR to enhance geriatrics education is vast, given its ability to now create those complex interdisciplinary teams, the nursing home scenarios, the locked dementia units, the wound care complexities. If we applied AR over existing simulation, we have the potential to create the home safety environments that a geriatrician needs to perform functional assessments.

TECHNOLOGY IN GERIATRIC MEDICAL EDUCATION

Although technological advances continue to reshape global social, economic, and scientific landscapes, few technological solutions currently address the growing need for physicians serving in geriatric medicine in the United States. Recent proposals by Golden, Silverman, and Issenberg (2015) to increase geriatrician numbers suggested abbreviated specialized training programs similar to those of nurse practitioners, or offering financial incentives to attract more qualified residents to the field; however, these ideas require further expansion and refinement to clearly identify ways in which the stated goals could reasonably be achieved. One step in the right direction involves harnessing technology to fundamentally transform existing medical–educational paradigms, particularly for aspiring physicians seeking service in geriatric medicine.

The Institute of Medicine's *Retooling for an Aging America* (Institute of Medicine of the National Academies, 2007) addressed rising health care costs associated with aging populations and physician shortages, endorsing a philosophy of "retooling" collective approaches to devise innovative solutions and growth of the geriatric population's health care workforce. The institute's paper established guiding principles upon which current notions of educational reform and allocation of resources to implement novel educational technologies among allopathic and osteopathic medical training programs in the United States have been built. Drake's (2013) "Retrospective and Prospective Look at Medical Education," for example, reviewed ongoing changes in approaches to teaching the anatomical sciences in medical school today. His paper encouraged university administrators and program directors to embrace creativity and focus on devising curricula geared toward active learning and longitudinal approaches. To accomplish these objectives, we must carefully examine traditional undergraduate and graduate medical training programs, and seek ways to implement high-tech, self-paced, competency-based educational paradigms. Such shifts in medical education would also accelerate professional qualification and significantly reduce financial burdens for trainees, ultimately helping to incentivize and meet the rising demand for geriatricians.

SLOW TO CHANGE

While ostensibly, medical education is likely to benefit from the implementation of new technologies, medical organizations can be slow to embrace innovation, with hospital and university-based systems resisting the costs and institutional difficulties associated with implementing new technologies. Current models of undergraduate medical education remain largely based on 4-year models first developed at Johns Hopkins in the 1870s and championed by Abraham Flexner in 1910, as part of his landmark critique that spurred the first radical curricular reforms in the United States. As Ludmerer

(2010) pointed out in his "Understanding the Flexner Report," many of Flexner's reforms are still current today; however, Flexner would likely endorse efforts to reform his own system, so long as those reforms were in the best interests of the students, the medical profession, and the general public good.

Confronting an increasingly complex and rapidly expanding body of scientific discovery and peer-reviewed literature, medical schools and residency-training programs have begun to embrace certain types of technology to facilitate pedagogical, informational, clinical, and heuristic aspects of training; however, the overarching structure of medical education remains largely unchanged over the past 100 years. Moving to embrace and implement novel technologies could provide revolutionary changes required to provoke a 21st-century Flexnerian reform, and address critical shortages in primary and geriatric medicine faced today.

In addition to costs and administrative challenges associated with institutional reforms, the emphasis on standardization and accreditation processes, emergence of profitable tuition-payment schedules for universities and graduate-education funding, and difficulties replacing regimented time-based curricula also contribute to the hesitancy to broadly change medical education. The Carnegie Foundation's 2010 modernization of the Flexner Report, *Educating Physicians: A Call for Reform of Medical Schools and Residency Programs* (Cooke, Irby, & Obrien, 2010), made medical educational reform a hot topic once again within the academic literature. The authors of the Carnegie report called for changes along the lines of greater integration of academics with clinical experiences, individualization of the learning process, trainee commitment to excellence, and professional-identity development in medical educational systems. Although technology is mentioned as a way to help bridge the gap between academics and the clinic, technological innovation in today's medical training pipeline could help to accomplish each of these four objectives. Medical education offers an environment ripe for technological change, one in which innovational risks can be taken to improve and streamline training processes.

CURRENT TECHNOLOGY IN MEDICAL EDUCATION

Typical geriatricians spend 4 years completing an undergraduate degree, 4 years in medical school, 3 years in an internal or family medicine residency program, and 1 or 2 years in a geriatrics fellowship. Geriatric medicine physicians spend at least 12 years pursuing the necessary academic training to obtain board certification and eventually begin clinical practice. With respect to other phases of medical training, geriatrics fellowships around the country also do not frequently utilize simulation-based or other technological means to enhance educational outcomes, instead opting for additional patient-based contacts and logging hours on the inpatient wards or visiting numerous outpatient clinics. This approach is at odds with the many suggestions for technological reform in today's medical educational pipeline, as it focuses on chronological benchmarks rather than competency—or skills-based protocols for graduation. Geriatric training often requires hands-on training with cognitively impaired patients, their families, large interprofessional teams that are difficult to create through a simulation lab as the settings do not occur or mimic adult day health centers, skilled nursing homes, dementia locked wards where many geriatricians practice. The single manikin simulation does not present the functional limitation assessments most geriatricians need to perform in assessments of gait, truncal stability, and activities of daily living skills. The large interdisciplinary teams create challenges and training inefficiencies in geriatric training.

Taking a look at medical education today, some medical schools began experimenting with accelerated curricula for students entering primary care specialties. Medical education is considered a nonterminal degree, meaning a physician after graduation with an MD cannot practice medicine without added clinical internship or residency training. Thus, the basic 4 years of medical education within medical schools is termed *undergraduate medical education* (UME), whereas the added clinical internship, residencies, and fellowships are termed *graduate medical education* (GME). The vast majority of undergraduate medical programs still follow the traditional 2+2 methodology, spending 2 years learning preclinical basic sciences and 2 years in on-the-job training set in clinical environments, irrespective of students' chosen medical specialties. During the first 2 preclinical years, students generally experience traditional lectures, small group sessions, interactive laboratories, and regular multiple-choice examinations. While these methods help to build a foundation in basic clinical sciences for medical students, the rapid expansion of knowledge and widespread cross-disciplinary collaboration in science makes it difficult for educators to consistently keep content up to date and current within traditional curricula. As described earlier, however, this problem could be addressed by relying more heavily on LMS models, flipped classrooms that deliver lectures electronically and follow with interactive sessions, or other technological innovations that move away from the physical lecture hall. Many of the basic science lectures, such as physiology, can be adequately covered through online portals.

PRECLINICAL YEARS

Preclinical medical students utilize some technologies designed to improve pedagogical, informational, and heuristic aspects of their training; however, these technologies are largely limited to computer-based approaches and are not directed toward maximizing competency or the rapid production of highly capable physicians. As with general education in secondary and postsecondary universities, undergraduate and graduate medical programs typically employ basic computing and networking technologies to deliver curricular content. According to the Association of American Medical Colleges (AAMC) Institute for Improving Medical Education (2007), the most common uses of technology today in medical classrooms include computer-aided instruction (CAI), virtual patients, and human-patient simulation. As implied by the term, technology in the form of CAI among preclinical medical students is largely driven by the ubiquity of computers and mobile technology. From a pedagogical standpoint, medical school faculty can utilize CAI to improve delivery and augment their educational content. Assuming that all students own desktops, laptops, or mobile-computing systems, employment of e-learning and flipped classroom models are also becoming more common fixtures in medical education, although not across the full spectrum of accredited allopathic and osteopathic medical schools.

Medical schools now also heavily leverage mobile-computing platforms, such as tablets and smartphones, with some schools even providing new iPads or other mobile devices to students upon admission, with the devices often preloaded with software, textbooks, and other clinical tools to facilitate learning and collaboration. Such concepts build upon popular existing constructs of social media, such as Facebook, Twitter, and Skype, with students receiving push notifications or regularly interacting on a virtual basis with colleagues and staff via their mobile devices. From an informational standpoint, this basic technology also contributes to medical education as a means to organize and collect data, provide secure environments for student testing and evaluation, and create online student environments that enable surveys, personal data management, and data-sharing applications.

In terms of heuristic applications, technology is one of the biggest drivers for individual success in medical schools today. Also based on computing and online networks, students today have many opportunities to seek out information required during medical coursework beyond standard prescribed textbooks and primary resources. Wide online content now exists, aimed at distilling information down to the key topics that students must master for success in class and on national licensing examinations. Examples include online histology, anatomy, and pathology resources; free Youtube, Khan

Academy, Coursera, and other video content; paid packaged online lecture programs such as Osmosis, Pathoma, Online MedEd; online test question banks such as USMLE World, Kaplan, USMLE Rx; spaced-repetition electronic flashcard programs, such as Osmosis, Firecracker, or Anki; Wiki-style or GoogleDoc collaborative writing software; and picture- or story-based learning modules such as Sketchy Medical and Picmonic. These examples outline just a few of the resources available to today's preclinical medical student, with online subscription-based and free content expanding at a rapid pace. The widespread use of such services by students as they prepare for standardized examinations introduces new research questions, including the pitfalls and dangers associated with accuracy and reliability of material not officially sanctioned by accredited medical schools; the performance metrics of such students versus those who utilize only school-delivered content; and reassessment of financial burdens faced by students today.

CLINICAL YEARS, RESIDENCY, AND FELLOWSHIP

As medical students transition to their third and fourth years, the curriculum pivots and focuses on the acquisition of clinical skills to be learned on the job in hospital wards and outpatient clinics, under the supervision of resident and attending physicians. The UME curriculum in these clinical years does provide some geriatrics exposure, but this is not intensive in dedicated blocks of time, such as seen with pediatrics, obstetrics, or even neurology. Owing to traditional rotational requirements, faculty access, and resources, many medical schools simply sprinkle geriatrics content throughout the 4 years of medical school, instead of placing a core intensive block dedicated to geriatrics. While students may be tested on their abilities to clinically examine standardized patients during this time, the majority of clinical experience is built working with real patients and while rotating through the various hospital wards. Experiences during this phase of training are often highly variable from school to school, and even among trainees at the same school, depending on students' timing through various clinical blocks. Trainee evaluations are typically based on subjective evaluations by supervising physicians and objective scores on standardized shelf examinations in the various clinical sciences, offered by the National Board of Medical Examiners. Because much of the second half of medical school is spent directly engaged in patient care and participating in real clinical medical scenarios, the educational emphasis also typically shifts from book-based knowledge to a more practical study of clinical techniques, reasoning, and management skills. As such, the use of technology during this time of training still includes many of the heuristic examples for personal study outside of working hours; however, technological advancements applicable to these clinical years are mostly evident in the transition to simulation-based training.

Simulation-based training is one aspect of medical education that has been around for a while. However, from the early days of cardiopulmonary resuscitation (CPR) training on unrealistic plastic manikins of decades ago, modern simulation-based training has become much more sophisticated, with lifelike robots and models that mimic the behavior of real patients. As Motola, Devine, Hyun, Sullivan, and Issenberg described (2013), older simulation models were improved by emulating various other industries with rich histories of simulation training, including aviation, military, and space organizations, which continue to advance us toward new frontiers for medical education. As the AAMC defined it in 2007, the purpose of various simulation models in medical education is to "simulate patient care environments for instructional or assessment purposes" and to "simulate specific procedural tasks."

Given increased demands placed on today's medical trainees at all levels, and the greater emphasis placed on safety protocols and team-based medicine, simulation-based training serves as an efficient means to practice in realistic scenarios, yet without the risks of practicing techniques on live patients. As such, simulation-based training serves as the mainstay for clinical years and postgraduate training, demonstrating one critical area in which technology provides a means to demonstrate clinical competency and reinforce institutional protocols. Patient-simulation drills also serve to build teamwork and efficiency among staff members, prepare trainees for challenging clinical encounters, and improve patient safety. As Motola et al. describe (2013), significant efforts among medical educational researchers are currently directed toward evaluating ways in which simulation-based training can be more effectively integrated into modern training programs, and how more realistic and powerful simulation models can be developed: These efforts are likely to move from manikin-based and physical simulation toward AR and VR models, as computing and graphics-processing technologies advance.

CONCLUSION

Technological advances are dramatically changing medical education and real clinical medicine to involve mobile applications that can perform a wide range of diagnostic and clinical tests, information highly valuable to medical students and residents working in the hospital. For example, students, nurses, and other clinical staff can now perform funduscopic exams, collect temperature and pulse-oximetry data, and gauge neurological tremors and heart rates using the powerful computing technology and application-based flexibility of mobile smartphones. Smartphone applications and enhanced camera adapters allow even lay people to take funduscopic images as these products can be searched and purchased direct to consumer on the Internet. Physicians and pharmacists also have ready volumes of reference material and pharmaceutical dosing calculators at their fingertips. The wide array of mobile-platform applications that can aid in clinical examination, diagnosis, and treatment will continue to expand, as user feedback and innovations in engineering drive future advances in technology. Applications, phone-embedded sensor technology, and the ease of creating new applications and mobile sites creates a creative environment wherein new medical direct-to-consumer grade products and tools are created daily without validation or testing.

It is incumbent upon practitioners to stay current with new technologies, especially as they are utilized by their patient populations. These promising new tools offer new ways for both practitioners and patients, especially when used to augment traditional teaching methods, while enhancing learning, safety, and comprehension. However, more research is needed in order to identify which tools are most effective as educational instruments for various populations. Therefore, new research should focus on segmenting learning groups to ascertain which methods may produce the best outcomes.

Health technology is constantly advancing and health care practitioners must be ready to adapt as new tools are created. We must ensure our professions are well represented during the development of these tools and utilize them throughout our education. From emerging artificial intelligence technologies such as cognitive computing and "smart" manikins, to VR and AR, clinical representation is vital to ensure that these tools meet the needs of both practitioners and patients.

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