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The Blue Ridge Academic Health Group

Report 17. Health Professions Education: Accelerating Innovation Through Technology

Health Professions Education: Accelerating Innovation Through Technology is the 17th in a series of reports produced by the Blue Ridge Academic Health Group.

MISSION: The Blue Ridge Academic Health Group seeks to take a societal view of health and health care needs and to identify recommendations for academic health centers (AHCs) to help create greater value for society. The Blue Ridge Group also recommends public policies to enable AHCs to accomplish these ends.

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(August 2012 meeting)

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Introduction

Our academic health centers are white-knuckled in fear that their historic missions of education, service and research are threatened from the outside. . . . Yet, a greater threat may lie within the halls of academe. If we remain dedicated to minor revisions of past educational approaches, our prospects will be dim indeed. (Don E. Detmer, MD, 1997)[1]

We are reaching a tipping point where education and educators can use technology to reach almost every person on the planet inexpensively. However, the result may not look like the conventional university experience we recognize today. These are exciting times for educators, but it remains to be seen how these developments will change the structure of education, influence the purpose of institutions, and shape the role of professors. These developments may feel threatening, but they also offer exciting opportunities to reach a much larger and broader audience with our lectures, to spend more time advising and mentoring students, and to improve the overall learning experience for all. (Stephen Carson and Jan Philipp Schmidt, 2012)[2]

Over the past decade, a multitude of organizations have called for the reform, overhaul, and transformation of health professions education.[3-16] Although there may be differences in emphasis among these groups, there is widespread agreement on the nature of needed changes. In general, health professions education needs to do the following:

- Expand focus on new areas that are foundational to the success of clinicians in the 21st century (e.g., working in teams, patient-centeredness, communication, informatics, population-based and evidence-based care).
- Strengthen ability to measure competencies of learners.
- Improve efficiency of the educational process and address issue of costs required to become a health professional.
- Be responsive to the learning styles of students.
- Prepare students to be lifelong learners.
- Produce an adequate number and appropriate balance of health professionals.

Achieving these objectives will impact health professional schools' curricula, faculty, infrastructure requirements, and budgets in addition to requiring changes in organizational culture. While the tripartite mission of an academic health center (AHC) yields organizational synergies, it also results in the educational enterprise competing with patient care and research for limited resources. Moreover, some of the needed changes are beyond the control of academic health centers. Indeed, well-intentioned unilateral actions may have unintended consequences. Hence, there is a need for coordination and thoughtful participation of all the stakeholders involved, including the organizations that accredit schools, certify and license health professionals, and pay for patient care. The task of educational reform is vast and complex; multiple actors must align their policies; uncertainty abounds and is exacerbated by the changes under way within the health care system; and scarce resources make it critical that any changes be made with great care and thought. Despite a growing sense of urgency, progress has been slow. As a result, the evolution of educational approaches has not kept pace with market changes and innovations in health care delivery, and health professional educational processes are not aligned with health system needs.

Meanwhile, online learning (also known as e-learning, Internet-based learning, Web-based instruction, distance learning, computer-aided instruction) is on the rise and creating waves, if not a tsunami, for higher education.[17] In 2012, online learning reached a new milestone with the emergence of massive open online courses or "MOOCs" and accompanying for-profit and nonprofit platforms that provide access to MOOCs. Of particular note, Stanford's free online course on artificial intelligence attracted 160,000 students from 190 countries (with 5% of students completing the course); a president of a top-ranked university was ousted in part for failing to respond quickly enough to the online course environment (but was later reinstated); and *The Chronicle of Higher Education, The New York Times,* and *Time* each focused on MOOCs and the reinvention of higher education within the span of a month.[17-22]

These developments are occurring against the

backdrop of increasing questions about the ever rising cost and value of traditional residential education.[23] Despite facing ambiguity on the effectiveness of online educational approaches, perceived threats by faculty, and additional costs for already burdened budgets, universities have been forced to grapple with the online learning movement and to determine whether and how to incorporate it into daily operations, and they are being pushed to do so at a more rapid pace than they are accustomed to moving. Higher education institutions stand at a pivotal juncture, with opinions divided on what the future holds. Some observers predict that higher education will change more in the next decade than in the past 100 years and that 50% of the colleges and universities operating in the United States in 2013 will not exist in 2063.[24] Other analysts contend that it will take a decade for solid business models for MOOCs to emerge, and still others caution that some for-profit online education companies entering the market are a "sack of vapor."[25, 26]

These disparate developments—the need for health professional education reform and the online movement—present leaders of AHCs and health professional schools with a compelling, indeed critical set of questions that motivates this report:

In light of the complexity associated with needed reforms, what can health professional schools and academic health centers do in the near term to make progress toward the envisioned future for health professions education?

How can AHCs and health professional schools capitalize on the potential benefits offered by online learning and computer-assisted instruction to move toward our shared vision for health professions education?

How can health professional schools and AHCs leverage education technology to jump-start needed changes in health professional education and accelerate innovations that will pave the way for longer term and larger scale transformations?

The Blue Ridge Academic Health Group (Blue Ridge Group) begins this report with the endpoint—the desired destination for health professions education—and ends the report with a set of recommendations for moving toward that destination. Given the anticipated fast pace of change in online education, the report challenges AHCs to embrace a small set of immediate actions that can be implemented while the longer term recommendations are being progressively adopted. This report will not explore in depth the full range of actions that are needed to achieve optimal reform of health professions education. The Blue Ridge Group recognizes that the recommendations in this report are insufficient to achieve the ultimate end goal but believes that there are actions that can move toward the endpoint and that, by building momentum and gaining experience, larger changes may be stimulated.

How can health professional schools and AHCs leverage education technology to jump-start needed changes in health professional education and accelerate innovations that will pave the way for longer term and larger scale transformations?

To understand how AHCs should respond to the need for dramatic changes in health professions education and the rapidly changing higher education landscape, the Blue Ridge Group surveyed initiatives and institutions on the frontier of higher education and health professions education innovation. These "bright spots" do not provide a simple answer to how to reform, transform, advance, or overhaul health professions education.[27] They do, however, help us understand the forces that are shaping higher education and highlight how AHCs can take advantage of emerging tools to jump-start progress toward our desired destination.

The rapid pace of change and daily reports of new developments in the online movement required the Blue Ridge Group to take a snapshot in time (i.e., fall 2012) as the basis of its analysis. This report focuses on health professional undergraduate education (e.g., in schools of medicine and nursing) rather than the entire education continuum being impacted by online learning (i.e., elementary school through continuing professional education).

The destination: A multi-faceted vision for health professions education

Two key concepts underpin the work of the Blue Ridge Group. First is the need for AHCs to meet the needs of society as well as the individual needs of the patients they serve and the students they teach. Second is the concept of a value-driven health system and the need to maximize return on investment for dollars spent in health care, education, and research. Building on the vision for health professions education that has emerged over the past decade, the Blue Ridge Group explicitly applies these two concepts to its understanding of what health professions education should offer in the future and articulates the vision for health professions education from the perspective of four key stakeholders.

From society's perspective, health professional education should do the following do the following:

- Produce an adequate number and appropriate balance of health professionals as needed to meet the needs of the population. This includes achieving greater representation of historically under-represented minorities across the health professions.
- Ensure that all health professionals are competent in their respective domains, proficient in working in teams that include patients and families and that cross a range of settings, and able to work in a learning-oriented and technology-facilitated health care delivery system.
- Produce health professionals who are prepared to evolve in response to the changing needs of the population and the health care system.
- Yield a positive return on public investment in health professions education.

From the health professional student's perspective, health professional education should do the following:

- Be flexible,
  - allowing students to move as quickly or slowly through the content as needed to gain mastery, taking into account their knowledge and strengths upon entry to health professional school and their ultimate objectives for practice, and
  - allowing students to use the educational methodologies/tools that best suit their learning styles.
- Enable each student to achieve mastery in his/her domain while also gaining proficiency in functioning effectively in a multi-disciplinary, inter-professional team; in a learning health care system; and as a lifelong learner.
- Minimize the time required to become competent by exposing students to knowledge that is truly relevant and providing experiences that are essential to achieving competency.
- Be integrated over time as health professionals move from undergraduate to clinical practice (or in the case of physicians, from premedical to undergraduate medical to residency and fellowships, to practice).
- Be affordable.

From the faculty member's perspective, health professional education should do the following:

- Be valued, supported, and rewarded by the organization (i.e., academic health center).
- Provide opportunities for innovation and collaboration across disciplines and institutions.
- Provide opportunities to engage students in learning activities that promote collaboration and personal growth for teachers and learners.

From the academic health center's perspective, health professional education should do the following:

- Attract a diverse population of students.
- Engage faculty and allow them to focus on skills and knowledge that are best transmitted through personal interaction with and among students.
- Capture and track costs and quality outcomes.
- Be self-supporting.

Some of the changes needed to achieve this vision depend on actions by groups outside of AHCs. For example, time must be found to address new areas in the curricula without increasing the length of training. Rather than add these important areas on top of the existing curriculum, institutions will need to reduce time spent on some areas within the current curriculum. Yet schools cannot risk making these changes unilaterally since students must pass the licensing board exams, which are based on the current curriculum. In the case of medicine, the Federation

of State Medical Boards will need to agree to such changes. But equally challenging, all of the disciplines that are currently represented in the curriculum will need to agree on the determination of what constitutes "core" content and a reallocation of time in the curriculum. A comprehensive examination of such changes is beyond the scope of this report but is a desired task that needs to be "owned" by relevant educational organizations. Rather, this report explores which elements of the vision for health professions education can be supported through creative, thoughtful application of currently available and emerging online learning approaches and tools that are accessible to and within the purview of AHCs.

This vision for health professions education creates additional requirements for the educational enterprise of AHCs and health professional schools. Specifically, AHCs and health professional schools jointly need to do the following:

- Foster far greater flexibility in educational processes to accommodate the individual student's starting point, learning style, life situation, and long-term objectives and to give students and graduates far more control of when, where, how, and what to study as they work toward achieving the needed competencies.
- Be more nimble with respect to modifying the curriculum and performance improvement efforts within AHCs, introducing advances in clinical knowledge or pedagogy innovations based on the science of human cognition, adapting to changing demands for numbers and types of health professionals, and overcoming timing constraints often faced in interdisciplinary training.
- Provide as many opportunities as each student needs to master competencies and capture and document student performance across time and settings.
- Measure and track costs and effectiveness for each component of the educational enterprise (e.g., individual lectures and simulations) and find efficiencies that save money for the institution and time (and money) for students.
- Implement technological innovations that support curricular changes and process enhancements.

The changing landscape of higher education

In fall 2010, more than 6.1 million students in degree-granting postsecondary institutions (31%) were enrolled in at least one online class.[28] The growth rate for online enrollment slowed somewhat in 2010 but continued to exceed the rate of growth in total higher education student population. The online movement is notable, not only for its size, but also for the many variations it takes. Traditional residential universities that offer online certificate or extension programs have been joined by purely online universities (both for-profit and nonprofit). The University of Massachusetts offers 25 different online bachelor degree options through UMassOnline and makes no distinction between online and on-campus credits earned.[29] The for-profit University of Phoenix had more than 450,000 students enrolled in 2010.[30] Western Governor's University (WGU), a private, nonprofit, multi-state online learning university with 20,000 students, charges less than $3,000 for tuition for a flat-rate six-month term and has not raised tuition for four years.[31]

This movement is by no means limited to higher education and reaches down to kindergarten. For example, more than 6 million unique users access the Khan Academy's free library of 4,000 videos each month. These short videos are aimed at K-12 learners, focus primarily on math and science, and are supplemented by problem sets that enable students to demonstrate mastery of concepts.[32] As time passes, increasing numbers of students entering college will have had some kind of online learning experience.

As Table 1 highlights, college and university students are likely to encounter a range of course types during their post-secondary education. In some online courses, a student may hear a recorded lecture that is synchronized to a set of slides, take online tests, and sometimes have the opportunity to participate in online discussion groups (with or without a faculty member). In other instances, considerable resources are invested in developing highly interactive learning modules that may include animations, interactive diagrams, and simulations with embedded assess-

Table 1: The range of online learning experiences that have emerged in higher education[28]

Course type	General description
Traditional	"Sage on the stage." Content is presented orally or in writing. There is face-to-face interaction between students and instructors. Some technology such as "clickers" or student response systems may be used in large classes to facilitate student interaction.
Web-facilitated	Web-based technology such as a learning management system is used to support a face-to-face course. Course materials such as the syllabus and assignments may be posted online. Tests may be administered online.
Blended/hybrid/ flipped	Substantial portion of content is delivered online; often reduces number of face-to-face meetings; may use online discussions among students and instructors. Students may be expected to view a recorded lecture before class. Face-to-face sessions can then be interactive learning experiences designed to activate prior knowledge and solidify understanding.
Online course	The majority or all of content is delivered online; may use online discussion; no face-to-face meetings.

ments.[30] Regardless of the level of interactivity provided in an online course, a technological infrastructure in the form of a learning management system that allows content sharing and tracking of student progress is essential.

While the scale of online learning is impressive, much of it replicates what has gone on in the classroom for centuries and merely constitutes a change in distribution method.[21] Although human cognition research has expanded understanding of how people learn, these insights have largely not yet made their way into most physical or virtual classrooms.

Nonetheless, applying online technology to current teaching processes does yield benefits. A 2012 study that compared traditional lectures (i.e., three to four hours of face-to-face instruction per week) to a hybrid format (i.e., machine-guided instruction combined with one hour of face-to-face instruction) found that learning outcomes were essentially the same for the two formats.[33] Cost simulations based on these results led researchers to conclude that the hybrid instruction model applied to large introductory classes offers potential to reduce instructor compensation costs in the long run. In addition to allowing faculty to teach more students in a single course, online courses reduce classroom space needs for universities, extend reach of the university beyond the campus, and eliminate the need for faculty to give the same lectures each semester, thereby freeing them up for other activities. Online courses offer students more flexibility with respect to when and how often they receive knowledge as students can listen to a lecture at a time of their own choosing and as often as they want.

Of potentially greater significance, online educational approaches offer tangible ways to transform the educational process. There is growing realization that traditional didactic lectures are less effective at achieving student mastery of knowledge than lessons that incorporate student problem solving.[34, 35] By reducing time required to lecture during face-to-face sessions, faculty can increase time spent engaging students in discussion or problem-solving activities. Learning management systems offer the capacity to capture data on individual learner progression, thereby enabling a customized educational experience. For example, the Khan Academy tracks student progress in solving problems and when a student demonstrates mastery of a given concept, it recommends new topics for the student to explore. Further, as organizations compile data for

Table 2: Evolution in access to higher education courses and courseware

Traditional closed courses	OpenCourseWare (OCW)	Massive open online courses (MOOCS)
Students pay tuition for access to content that is delivered face-to-face or online. Time frame for courses is controlled by institution. Online closed courses allow students some flexibility within the overall structure. Students who meet institutional requirements earn a degree.	Course materials originally designed for use within degree granting programs are made freely available for use at any time. They are not intended to serve as a stand-alone course, and there is no opportunity to earn a formally recognized credential.	Free courses that require registration. MOOCs are offered during a finite period. Students have flexibility within the general structure of the course. Students who meet requirements may earn a credential that verifies they have successfully completed the course.

populations of students, they have greater ability to analyze the effectiveness of specific learning modules and to gain insights into how students learn most effectively.

Two developments associated with the online learning movement—the idea of sharing course content for free and the platforms that enable such sharing with large numbers of students—may ultimately provide the tipping point for the reinvention of higher education. As Table 2 outlines, online courses and course content have expanded from the traditional closed model to include open access to courseware and free course offerings from elite institutions. Although these innovations are focused on external audiences for colleges and universities, they are also impacting the education of students on campus.

OpenCourseWare (OCW) is based on the premise that there is value in freely sharing courseware that has been developed for use in face-to-face courses.[36] Courseware may include syllabi, lecture notes, assignments, exams, and sometimes recorded lectures. It was originally intended for use as a teaching resource for educators around the world. Surprisingly, the majority of users turned out to be students looking to supplement their own instruction or self-learners curious about the topic. OCW began with a single institution (Massachusetts Institute of Technology) in 2002 and in 10 years has grown into a consortium of 280 institutions, 100 live OCW sites, and 21,000 courses. OCW inspired a broader movement of Open Educational Resources (OER) that includes an increasing number of open access journals and textbooks. OCW and OER have been enabled in large measure by the emergence of public copyright licenses such as Creative Commons, which gives licensors a standardized, easy way to grant copyright permissions to their work while retaining credit for it.[37] OCW content is not only supporting higher education around the globe, but it has also shown impact on communities. Two entrepreneurs in Haiti used MIT OCW content to learn about circuits to develop solar-powered street lights for use in some of Haiti's poorest communities.

The growth of OCW highlights several important lessons for higher education leaders:

- Educational content can be decoupled from those who create it. "Commoditizing" course content enables more efficient creation and use.
- There is strong demand for free content from trusted sources.
- There is a large pool of individuals worldwide who seek to learn for the sake of learning.
- A common technological platform that enables content sharing for a shared goal can foster greater and rather swifter collaboration than previously observed in higher education.

While OCW and OER continue to grow in size and influence, they have been joined by a growing set of **shared learning platforms** and **massive open online courses (MOOCs).** In late 2011, MIT formed MITx to support education on campus and around the world. This online interactive learning platform organizes and presents

Overview of a MOOC

In 2012, MITx offered a free online Circuits and Engineering (6.002) course for which 154,000 individuals registered and more than 7,100, or approximately 5%, passed the final exam. Students for this course ranged in age from 14 to 74 and represented 160 countries. The course included video lectures and demonstrations, practice exercise, homework assignments, exams, and an online interactive lab designed to replicate its real-world counterpart. A team of professors and teaching assistants supported a discussion forum and actively sought feedback from participants to improve the learning experience.[38] Some learners developed enhancements for the course such as online text viewers for mobile devices, while others requested that the website for the course be maintained after the course concluded so that students could continue interacting via the discussion forums, and still others used content from MIT's OpenCourseWare project to create their own follow-up course (i.e., 6.003z Signals and Systems).[39]

course material to enable students to learn at their own pace, includes online laboratories and discussion forums, enables assessment of individual students' work, and allows certification from MITx for students who demonstrate mastery. The sidebar describes the first MOOC offered by MITx. MIT has since partnered with Harvard to establish **edX,** a nonprofit online learning platform that offered seven free courses in 2012. The edX Consortium has expanded to include the University of Texas with its nine academic institutions and six health science centers, UC Berkeley, Georgetown, and Wellesley, with future plans to include several international universities.

Table 3: The four spheres of MIT's educational portfolio[40]

External	**OCW (OpenCourseWare)**	**Global MITx (MOOCs)**
	■ Comprehensive publication of materials used in MIT courses (~2,150 courses) ■ Targeted at learners and educators worldwide ■ Online communities ■ Dissemination platform for MIT faculty	■ MIT-caliber online courses with assessment and certificates ■ Targeted at top-level learners ■ Materials developed by faculty ■ Select portfolio of courses ■ Online communities ■ Delivered on edX platform
Internal	**MIT Residential**	**Residential MITx**
	■ Campus-based education ■ Faculty innovation in education ■ Re-imagines residential education via experiments ■ Blended online and classroom learning ■ Enhanced by MITx, OCW, and edX technologies	■ Online courses and modules for use in MIT's residential education programs ■ Targeted at MIT students ■ Online communities ■ Delivered on edX platform ■ Experimentation into how online courses can enhance campus-based instruction

As outlined in Table 3, MIT's educational portfolio has evolved to include four inter-related spheres of activity. As a result of its leadership in open courseware and nonprofit approach to a shared learning platform, MIT has positioned itself to expand the impact of its faculty globally through OCW, extend its reach to students who can successfully complete MITx courses, and create an infrastructure that allows continual learning about effectiveness of its instructional approaches and extends the capacity of its faculty for residential students by reducing the time required for lecturing.

MIT is not alone in this arena. In 2010, **Udemy** (www.udemy.com) was launched as a way for individual instructors to share their online course content for free or for a small fee that goes to the instructor. In 2012, two Stanford University professors offered an artificial intelligence course online for free. More than 160,000 students registered for the course and although only 5% finished it, 8,000 students in one term constitute considerable reach. Of note, the course was designed with short lectures (i.e., eight minutes) and many problems that force students to learn by doing. Along the way, faculty modified the course based on feedback from students and determined when quiz questions were unclear based on the number of students who missed them. Further, students developed enhancements for the course such as interactive tools for practicing what they were studying and translating the course into other languages. The professors who offered this course went on to found **Udacity** (https://www.udacity.com/), a for-profit venture for offering MOOCs that as of October 2012 had 400,000 registered students from 125 countries and offered 14 courses.

In 2012, two other Stanford professors created **Coursera,** a company that "partners with the top universities in the world to offer courses online for anyone to take, for free."[41] Both Coursera and the universities incur costs in developing and offering the courses; contracts stipulate that if a revenue stream emerges, the company and universities will share it. As of October 2012, 33 universities had joined Coursera, and 200 courses were in the course catalog. This set of universities creates a pool of 1.4 million students. In February 2013, the American Council on Education's College Credit Recommendation Service recommended college credit for five courses offered by Coursera. Another organization, **Course Gateway** (http://www.coursegateway.com/), seeks to meet global demand for post-secondary education and is focusing on "licensing and bundling online courses to provide customized curricula to both single and aggregated institutional buyers."

This is a rapidly evolving market with new players and concepts appearing almost daily. For instance, in fall 2012 four open education sites (Peer 2 Peer University, OpenStudy, Codecademy, and MIT OCW) launched a "mechanical MOOC" to teach a computer programming language without a professor using existing open courseware, online tools, and an email distribution list.[42]

It is also an uncertain market. Past efforts to monetize online learning failed,[30] and revenue streams for these newly formed companies have not yet crystalized. Nonetheless, the rapidly changing milieu has created the sense that universities need to jump in or risk getting left behind. And while free access to university courses is growing exponentially, consumers will be faced with the need to judge the quality of the content offered.

The growth of MOOCs and the learning management systems that support them pinpoint the power of having access to vast amounts of data on how students interact with courses and how well they master the content. A new era has arrived for the evaluation of the effectiveness of alternative instructional approaches. The potential to significantly increase our understanding of the factors that influence teaching effectiveness and learning and to build curricula and face-to-face and online courses that are based on that science represents a potentially huge leap for higher education.

Sharing content among institutions also offers the potential for dramatic change in higher education by reducing the costs of transmitting the knowledge to students while improving the quality of the learning experience. Rather than every college and university offering the same set of lectures each semester, they could choose to use recorded lectures from their own institution or elsewhere and use their time to work with students on activities that promote true mastery of

knowledge and critical thinking skills. Given the considerable resources it takes to create interactive online learning modules, development costs can be shared among institutions. Faculty and students can also provide feedback to the creators of the recorded lectures or interactive modules, thereby improving the quality of the course over time.

Robust online learning offerings provide institutions and students greater flexibility and control. Students may be able to select from a set of learning activities developed for different learning styles that help them achieve mastery of content, perhaps in less time. Faculty can obtain immediate feedback from students on what is or is not working in the course and make adjustments immediately if they so choose. All of these features contribute to the potential to improve the quality of educational processes while managing the cost of those processes. At their best, online learning technologies enable teachers to design lessons that take advantage of advances in cognitive/learning science in a way that the traditional lecture format fails to do, to provide a way to capture data on whether and how students are learning for further analysis and a deepening of the understanding of what works, and to respond to students' needs for flexibility in schedule as well as differing needs in time and approach for mastering content.

Essential components for building online capacity

The infrastructure for the educational process has become more complex with the advent of online learning and shared courses. While the basic elements of sharing content, interacting with students, assessing students, and credentialing students remain the same, what once required a professor, a classroom, and exam bluebooks now requires a way to convert content into an online format, store that content, provide access to the content asynchronously, interact with the students online, assess students' mastery of content, and track progress over time. Thus, in addition to faculty and physical space for blended courses, the online educational infrastructure must include **authoring tools** and/or a **learning content management system** to create and manage the content as well as an institutional **learning management system with embedded analytic tools** to provide student access to content, support interactive elements, offer both normative and summative assessments, and track student progress. Further, institutions that seek to share their content need to decide whether to join a **shared learning platform** (e.g., Coursera, edX, Udacity, or others) or to offer their content as OpenCourseWare. Finally, organizations need to develop internal capacity to support the development of online learning. Faculty need support in both technological and pedagogic dimensions of designing, creating, and implementing online courses or modules. They also need guidance on copyright and intellectual property issues associated with creation of online courses. Looking ahead, the learning management system for health professional schools will need to support and integrate with e-portfolios that enable competency validation for students and practitioners throughout their careers.

Leveraging technology for health education innovation

Online learning and computer-aided instruction efforts are already under way in many health professional schools. These tools are being used to facilitate knowledge acquisition, improve decision making, strengthen visual diagnosis (enhancing perception variation), improve skill coordination, practice rare and critical events, conduct team training, and improve psychomotor skills.[43] They range in level of interactivity for students, degree of fidelity in accurately simulating the intended task or environment, and resources required to develop. Table 4 presents examples of ways that health professional schools are using technology in support of education.

The challenge for AHCs and health professionals is to determine how these approaches can be used to strengthen their educational processes in the near term and to make progress toward a new vision for health professions education in the longer term. As they grapple with this challenge, AHCs and health professional schools must

consider the potential benefits, costs, limitations, and effectiveness of the technologies and approaches under consideration. There are scant data to answer these questions. Thus, as discussed subsequently in **Emerging Research Agenda,** significant attention must be given to formulating and implementing a robust research agenda. In the meantime, organizations will be well served to learn from efforts within and outside of their walls. Toward that end, several approaches to leveraging online technology and other educational technologies within health professional education are presented.

University of Michigan Medical School: Focus on continuous learners

The end is the beginning. Medical education is a continuum. However, for the initial formal phases of education there is a clear goal always in mind—namely, the preparation of an individual to provide clinical care for patients—a doctor. For decades we have presumed that time on task equated with appropriate levels of mastery of the abilities needed to become a physician. Over the last recent decades there has been an ever growing call for competency-based rather than time-based approaches to medical education. The explosion of technology-based learning and assessment tools potentially positions medical educators to move forward with competency-based educational models. (James Woolliscroft, MD, 2012)

The University of Michigan Medical School (UMMS) approach to building online learning capacity is shaped by several factors. UMMS begins with the competencies needed to graduate

Table 4: Examples of online learning and computer-aided instruction tools currently in use or in development at health professional schools

Online learning infrastructure (accessing content/measuring outcomes)
- Learning management system for accessing online courses and modules and tracking progress within them (within institution)
- Shared learning platforms (e.g., Coursera, OCW)
- ePortfolios for building longitudinal records of student and faculty performance

Knowledge transfer/acquisition
- Online/blended/hybrid/flipped courses (see Table 1), interactive learning modules such as case studies
- Apps for learning or practicing a specific skill

On-demand access to knowledge
- Online access to entire curriculum
- Availability of key resources on iPad or related technology
- Customized search engines for accessing institutional resources and beyond

Practicing skills and testing knowledge
- Virtual patients
- Virtual microscopes
- Simulation centers
- Simulated emails to assess knowledge, professionalism, and communication skills
- Spaced education games
- Serious games
- Avatars

and the student's personal goals. These competencies extend beyond mastery of facts to development of skills, attitudes, and habits associated with excellence in practice and lifelong learning. Thus, UMMS is working to create tools that allow students to practice synthesizing disparate information and accessing information and resources from a variety of sources as well as self-assessment and reflection. UMMS's approach is also motivated by the understanding that students do not study the way that faculty did and are more likely to follow their own pattern of learning. Finally, UMMS's view that technology can enhance learning and student assessment is balanced by recognition that rigorous evaluation of whether the actual transfer of skills is achieved is imperative.

The student portfolio (see Figure 1)[44] will be at the core of the University of Michigan Medical School's approach to achieving competency-based medical education. The interactive tool currently being developed as part of a comprehensively integrated learning architecture will support self-directed learning by helping students articulate their personal goals and plan their learning experiences, monitor their progress, reflect on their experiences, and access resources at the UMMS and beyond. It will also provide access to targeted learning objects tied to specific competencies.

The student portfolio will be supported by a range of online technology that is already being used to support self-directed learning and enhance traditional face-to-face classes. Among the initiatives under way at UMMS are the following:

Figure 1[44]

- First- and second-year lectures have been digitally recorded for ubiquitous search and access by students.
- The Professional Skill Builder (PSB), a web-based, multimedia, interactive case simulation program, allows students throughout their four years to work through clinical cases to practice history taking, physical examination, and diagnostic test selection, thereby reinforcing and integrating classroom and clinical learning.
- Third-year students have access to additional online cases through a subscription to iInTime, designed to address gaps and stimulate self-directed learning when students do not encounter specific core clinical conditions.
- The histology class is taught using virtual microscopy throughout the first year of medical school (www.med.umich.edu/histology/courseinfo.html).
- Simulated electronic mail has been tested as a way to improve third-year medical student electronic communication skills with patients and family members.
- Advanced Medical Therapeutics is a self-directed, interactive, on-line course that is required for fourth-year students, designed so that they build applied knowledge in the clinical context and fully participate in the course while traveling for residency interviews.
- iSeek allows all medical school students, faculty, and staff to search and view all online educational materials (including streamed lectures and PowerPoint presentations) in the undergraduate medical school curriculum, with future capabilities planned to search the medical literature and electronic health record.

Looking ahead, UMMS is testing the use of digital avatars in advanced communication scenarios and, in collaboration with Coursera, developing blended lecture snippets with embedded assessment to deliver full courses online. Looking more broadly, UMMS has been an active participant in open.michigan, an open courseware initiative of the University of Michigan that allows faculty to share their educational resources such as downloadable lectures, YouTube videos, and SlideShare presentations with the global learning community. As of October 2012, 98 UMMS faculty were participating and 13 M1 and 10 M2 sequences were available, with 263,987 views to 29 UMMS videos and 38,925 views to 214 UMMS lectures.

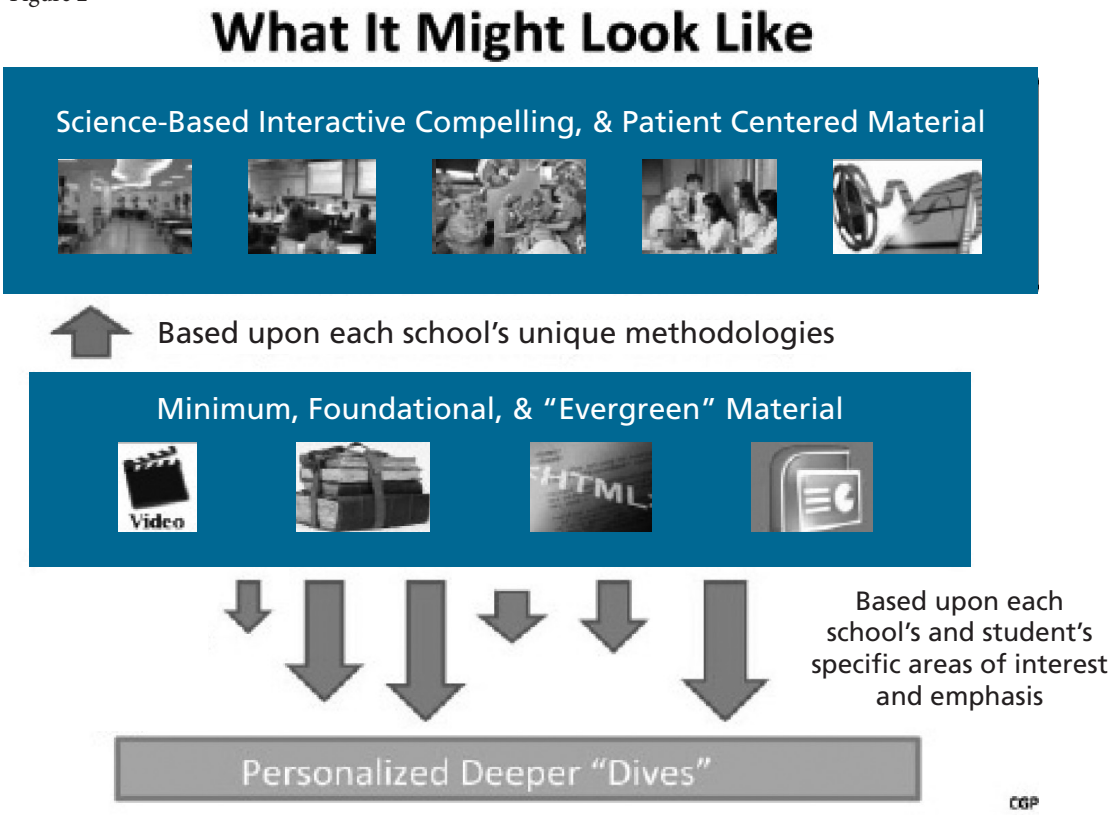
Stanford University: Flipping the classroom

Burgeoning and constantly expanding medical knowledge, the new generation of technologically savvy and enabled learners, and the rising costs of higher education demand the exploration of more efficient and effective modes of health professional education. The ability to produce and deliver high-fidelity content to local and widely dispersed learners on innovative platforms creates the opportunity to fundamentally alter the way in which health professionals can be educated. (Charles Prober, MD, 2012)

The Stanford School of Medicine approach to leveraging online learning is built upon a model that delineates three types of knowledge (material) that students will encounter. (See Figure 2). First, there is the foundation or core of knowledge that all students across all schools of medicine must master. Second, there is knowledge associated with "deeper dives" that individual students or institutions may choose to explore according to learners' personal interests and passions or institutional strengths and priorities. The opportunity to individualize learning experiences is an important element of this model. Third, mastery of both types of knowledge is aided by "science-based, interactive, compelling, and patient-centered material" that serves to engage the learners in ways that underscore the relevance of the core content and facilitate long-term retention of critical knowledge.

This model is exemplified in the recent redesign of the medical school's core biochemistry course, which eliminated most of the traditional lectures. In the place of lectures, instructors developed short online presentations that students were expected to view prior to class. Class time primarily was devoted to interactive discussions of case studies that highlighted the biochemical bases of various diseases. Student attendance for the optional interactive sessions rose to more than 80% from 30% attendance at the lectures the prior year.[45] Other interactive approaches identified for future flipped classes include multi-station exer-

Figure 2



cises, team-based problem solving, game playing, debates, live patient presentations, standardized patient interviews or examinations, and high-fidelity medical simulations.

The Stanford Medical Interactive Learning Initiative (SMILI) was developed to underscore the need to develop richly interactive sessions to complement any online instruction. SMILI facilitates the education of teachers and learners in the pedagogical basis and structure of interactive learning; organizes, conducts, and assesses pilot projects; and provides resources to help with the design, production, implementation, and assessment of courses utilizing some of the new learning strategies. SMILI's web presence (http://med.stanford.edu/smili/) was developed to expand understanding of the benefits of interactive learning and to encourage faculty to become involved. SMILI provides specific guidelines, based on pedagogical research, on how to structure effective video lectures (e.g., eight to 15 minutes in length, focused on a specific topic, enhanced with embedded quizzes, reinforced by reading materials and other resources).

In August 2012, Stanford University created an Office of the Vice Provost for Online Learning (VPOL). This is only the third vice-provost-level office created by the university in approximately 20 years and underscores the university's commitment to online learning. In November 2012, the VPOL invited faculty to submit proposals for online and blended courses that would provide an innovative learning experience and include a plan for researching the impact on student learning. This seed grant program has funded 31 faculty projects from across the university, including 10 at the School of Medicine.

Stanford also is pursuing collaboration opportunities such as developing platforms for hosting the didactic content and working with other academic health centers to contribute to content creation and strategies for the interactive sessions. The long-term goal is to improve medical education domestically and to facilitate distribution of medical knowledge globally.

New York University School of Medicine: Toward a knowledge syncytium

By establishing the Division of Educational Informatics (DEI) in 1987, New York University (NYU) created the foundation for leading-edge use of information technology in support of medical education. This division seeks to create a knowledge syncytium, "a learning and problem-solving environment which supports access to information unfettered by time and space."[46] In addition to building the infrastructure necessary to support online and computer-aided instruction within NYU, DEI has focused on providing students with access to all curricular content, creating applications that foster student-centered learning and that allow students to practice skills as often as needed, and sharing their content with other schools. DEI plays a key role in the implementation of NYU's new medical school curriculum, C21, and in collaboration with the NYU College of Nursing developed a curriculum to strengthen inter-professional education.

In addition to putting the entire curriculum from undergraduate to graduate medical education online so students can look ahead or back, DEI's activities include developing the following:

- e-Portfolios that will integrate qualitative and quantitative data on instructors and learners
- The Virtual Microscope that replaces uses of physical microscopes and allows students to navigate, annotate, and collaboratively view high-resolution digital histology slides. (This code has been released as open source.)
- WISE-MD modules that are web-based educational tools, designed for integration into the third-year medical student surgical clerkship curriculum. The modules present a comprehensive picture of patient care, including core knowledge, technical skills, professionalism, and the clinical reasoning skills that guide the physician's decision-making process. These modules are available for licensing through UMed (www.med-u.org).
- The BioDigital Human that allows students to view life-sized digital content on a screen in the anatomy lab as a supplement to their experience with cadavers
- VP21, a web-based experience that allows students to manage virtual patients and to collaborate in virtual teams (http://cloud.med.nyu.edu/ecosystem/)

With funding from the Macy Foundation, DEI collaborated with the NYU College of Nursing to develop a shared curriculum for nursing and medical students (NYU 3T: Teaching, Technology, Teamwork). The program comprises web-based learning modules, interdisciplinary team virtual patient assignments, a mannequin-based interprofessional simulation, and a clinical cross-over where nursing students shadow a physician and medical students shadow a nurse. Preliminary evaluation of the program showed that the computer-assisted instruction improved students' knowledge and that students showed positive changes in their attitudes.[47] The curriculum, including the web-based modules, virtual patient curriculum, and simulations cases are freely available from the NYU DEI site.

Johns Hopkins University School of Public Health: Extending reach and impact

While Johns Hopkins University's (JHU) interest in part-time education dates back more than 100 years, the Bloomberg School of Public Health (BSPH) established JHU's first formal distance education division in 1996. Motivated by the need to support researchers who were working on BSPH projects around the world, BSPH initially offered five online courses for 36 students. Today, BSPH offers 113 for-credit online courses for full- and part-time students working toward master's degrees. In 2005, BSPH launched its open courseware project as a way to get critical content in the hands of people who need it—especially public health workers grappling with urgent issues in the field. Today, BSPH provides access to the courseware for more than 100 courses. In 2012, JHU joined Coursera, and in a short period of time had eight courses on the platform and 175,000 students registered for these courses.

Like MIT, BSPH used OCW to extend its reach and meet global needs for its content. The degree-granting online programs provide flexibility to students who need to fit their studies around a full-time job. All of JHU's schools now offer online programs, with 16,000 students enrolled each semester. These programs are profitable and help maintain the fiscal strength of the individual

schools. Interestingly, previous conversations among the schools did not result in agreement to share a common learning management platform despite the potential to save costs by doing so. With the arrival of Coursera, however, there was unanimous interest in signing a university-wide agreement, which allowed the schools flexibility on when and how they posted courses on the Coursera site.

University of California-Irvine School of Medicine: iMedEd

UC Irvine has built a digital, interactive learning environment for its students. Since 2010, the iMedEd Initiative has provided each entering student an Apple iPad that houses the entire first-year curriculum, including outlines, handouts, and textbooks, as well as hundreds of medical applications (apps). The tablets have been updated to include course materials required for the second and third year as students have progressed forward in their studies. Complementary technologies such as digital stethoscopes and portable ultrasound devices with supporting instructional content enhance the learning experience. To maximize the benefit of this educational platform, lectures have been transformed to include short, topic-based podcasts and small-group discussions.

Emerging and maturing educational approaches

Technological advances, cognitive science, and new perspectives on existing educational tools are widening the range of educational approaches that health professional schools can use to enhance the learning of their students.

Electronic health records as a needed skill and as a learning tool

All health professional students need to learn how to use electronic health records (EHRs) to be proficient. They likely will encounter different EHRs over the course of their education and careers, so they need a general understanding of EHR systems and their effective use as well as exposure to different kinds of EHRs. Further, the increasingly available prompts and clinical decision support within the EHR also are educational tools. In a 2010 survey of medical school deans, more than 90% of respondents thought that excluding student notes from patient records would negatively impact education. A 2008 survey of third-year medical students in outpatient clinics reported that students asked more history questions and ordered more clinical preventive tests as a result of EHR prompts.[48]

Yet many hospitals do not allow students to enter notes into EHRs because of concerns about violations of Medicare fraud regulations on student notes and teaching physician use of such notes. Recent developments in the form of data "handles" may offer institutions a way to work around this constraint. In short, all data entered by a student could easily be tagged with a unique handle that allows faculty to review student notes and for student notes to be excluded from the official/legal record.[49] Alternatively, schools can provide access to EHR systems specifically designed for students. The University of Victoria developed the Interdisciplinary Electronic Health Record Educational Portal (UVicIED-EHR Portal), a web-based portal that provides students with access to multiple EHRs as a way for them to interact with the systems using "dummy" data and provide exposure to different EHR designs and features. The portal allows educators to "teach students how to effectively and efficiently use a HIS [health information system] in the safety of the classroom and laboratory setting."[50]

Spaced education: Applying cognitive science to improve knowledge retention

Spaced education (SE) is an online learning methodology based on psychological research that shows that educational encounters repeated over time increase acquisition and retention of knowledge and that the process of testing alters the learning process to improve knowledge retention.[51] SE can be applied across a wide range of topics and shared among institutions. In one trial of a spaced education game focused on anatomy, histology, cardiology, and endocrinology, students received an automated email containing a link to multiple choice questions.[52] Upon submitting an

answer to a multiple choice question, the student received the correct answer, a summary of the curricular learning points, explanations of why the answers were correct or incorrect, and links to additional educational material. The game would repeat the question in three weeks if answered incorrectly; six weeks if answered correctly. The goal of the game was to retire 100 questions so the length of the game depended on students' baseline knowledge and ability to learn and retain knowledge from the SE questions and answers. This game was well accepted by medical students and demonstrated effectiveness in teaching core content and validity in testing medical student knowledge.

Virtual patients: Health care's flight simulators

Virtual patients or computer-based clinical case simulations present students with real-life clinical scenarios that enable them "to emulate the roles of health care providers to obtain a history, conduct a physical exam, and make diagnostic and therapeutic decisions."[43] Virtual patients are often viewed as a safer and more efficient way for students to apply relevant knowledge and practice clinical skills. They provide a way for schools to ensure student exposure to both common and rare clinical conditions. Virtual patients vary in their design, implementation, and effectiveness.[53] They are accepted by students, particularly students who have had limited clinical contact.[54] Compared with no intervention, they are associated with higher learning outcomes. Compared with a non-computerized intervention, there is no or only a small effect. Beyond quantitative improvement, however, virtual patients address logistical barriers and provide opportunities for students to work in teams on the cases and provide interactive learning opportunities that can fit into the schedules of busy practitioners. This educational technology shows great promise as a way to tailor learning experiences to the needs of students but also requires rigorous evaluation to determine which formats and implementation approaches are most effective.

Simulation centers: The pinnacle of education technology?

Human patient simulation (HPS) uses mannequins or models to offer students an immersive, active experience; engage emotional and sensory learning; foster critical thought and communication; and animate basic science in clinical context. Such experiences require learners to synthesize knowledge and demonstrate skills before putting them into practice. Simulation centers provide a way for individual students to train for specific, complex tasks and for multi-disciplinary groups of students (and practitioners) to build competence in functioning as a team while grappling with realistic patient scenarios. Further, HPS allows students to demonstrate competency in specific areas. In nursing, simulations are often part of the screening process by employers.

Eighty-seven percent of nursing schools are using high-fidelity mannequins and are spending millions of dollars in resources and faculty time revamping curricula to incorporate simulation.[55] In some instances, schools are anticipating a future in which nurses will need to demonstrate proficiency in simulations to retain their licenses. In other cases, nursing schools are striving to expand their capacity. NYU College of Nursing (CON) has doubled in size to 800 students since 2007 and is challenged to find clinical sites and faculty to teach the increasing enrollment. As a result, NYU CON has committed to replace 50% of undergraduate clinical hospital time with simulation.

Medical schools are making large investments in simulation as well. In 2010, UC Irvine School of Medicine opened a 3,000-square-foot, state-of-the-art simulation facility that includes a multi-disciplinary critical care area that can be used to simulate an emergency department trauma bay, a full-scale operating room, a critical care unit, an obstetrics suite, or a patient ward.[56] Task trainers support diagnostic and therapeutic skills development. These facilities are being used to prepare medical and nursing students, residents, fellows, practicing physicians, and EMS personnel. They are equipped with teleconferencing and video recording so that teaching can be shared globally.

A recent meta-analysis of 609 technology-en-

hanced simulation training studies that compared simulation with no intervention (i.e., no training) concluded that simulation "is consistently associated with large effects of knowledge, skills, and behaviors and moderate effects for patient outcomes."[57] The authors noted that key questions remain on when and how to use simulation most effectively and cost-efficiently. Another recent meta-analysis of the effects of simulation training in central venous catheterization concluded that simulation-based education was associated with significant improvements in learner outcomes and with improved patient outcomes in some areas (i.e., fewer needle passes and pneumothorax) but was not associated with reduced risk in arterial puncture or catheter-related infections.[58]

The National Council of State Boards of Nursing has embarked on a three-year, 10 institution study that will compare the clinical competence of three cohorts of students who experience different levels of simulation as nursing students (50%, 25%, and 10%). Researchers will collect National Council Licensure Examination pass rates for the study students and will track the students through their first year of practice. Final results are expected in 2014.[59]

Potential benefits and limitations

The benefits of educational innovation enabled by technology can generally be characterized as improving the quality and efficiency of the education process. These technologies offer health professional schools the means to improve quality dimensions of specific concern for their students—tailoring learning experiences (including the need for repeated practice to master skills) and adapting to diverse learning styles, supporting team learning that fits into the varying schedules of health professional students, and assessing and tracking competency of students. They also offer the potential to educate increased numbers of health care professionals who are better prepared within and across disciplines to produce higher value health care for patients and society at a reduced cost per student. These benefits derive in large measure from four capabilities that are enabled by education technology:

- Authentic contexts for learning and assessment
- Uncoupling of instruction from place and time
- Standardization of instruction and assessment
- Greater ease in sharing content within and among institutions

Table 5 presents the potential benefits that stakeholder groups are likely to experience when institutions implement educational technology.

While educational innovation enabled by technology offers many potential benefits, it does not currently address all aspects of health professional education. Importantly, it does not fully replace personal interaction among faculty and students that are required for humanistic and ethics education and absorbing professionalism. It cannot replace role modeling, patient interaction, or real-time supervision and accompanying opportunities to observe practices such as "fuzzy logic" (i.e., decision making with imprecise data). It cannot assess or teach emotional intelligence and empathy. Educational technology can help students be fully prepared for their first interactions with patients, but only through real experience can students achieve true mastery. Purposeful integration of these approaches into the full continuum of health professional education and continuing education remains a challenge.

Obstacles

There are significant obstacles to achieving the vision for health professions education presented early in this report (see Table 6). The first hurdle to overcome is the collective inability within the health care community to imagine a different future for health professions education. Health education leaders must articulate a compelling vision that will enable myriad individuals and organizations to imagine a fundamental change in the paradigm of health professions education and stimulate them to take actions that lead to the envisioned future. Equally important, organizational cultures and leaders must adapt to implement needed changes and support the new paradigm. Organizational culture must shift from hierarchical, autonomous, competitive, individualistic, and

expert-centered to collaborative, team-based, service-based, mutually accountable, and patient- (or student-) centered.[60] So too, future leaders will need to focus on collaboration and team work, translational science, strategic thinking, and breakthrough approaches rather than individuals, basic or clinical science, tactics, and incremental approaches. They will need to be competence-centered rather than knowledge-centered and will face a more diverse workforce that values professional (including ethical) fulfillment over status and titles.

Systemic obstacles to achieving the vision must be confronted on multiple fronts—from pre-health education of students, to financing of graduate medical education, to the health care delivery system. The standard pre-health curriculum is not well aligned with emerging requirements for health professions students. Constraints on funding for GME slots prevent medical schools from increasing the number of students to meet anticipated health care needs. Within the delivery system, team-based approaches to providing patient care are the exception rather than the rule, and there has been little attention to or investment in team preparation by health care delivery organizations. As a result, students receive little exposure to team-oriented patient care during clinical rotations.

Perhaps most critical and daunting is the set of challenges associated with moving toward competency-based health professions education. As illustrated in Figure 3, a host of organizations influence the education and certification of health professionals. These groups face their own stakeholders and financial incentives that are often in conflict with desired changes in health professions education. Yet to make real progress toward the desired competency-based education of health professionals, these organizations will need to reach consensus on fundamental issues and invest in the development of tools and infrastructure that support competency-based education. Specifically, the following are needed:

- Clear definition and continued refinement of competencies within disciplines and identification of competencies that are common across all disciplines
- National assessment tools that assess the competencies beyond knowledge recall, including the ability to use technology
- Ability to move to the next level of training upon competency demonstration independent of formal training cycles/dates

While there has been some progress in these areas, such as the 2011 expert panel that identified core competencies for collaborative practice and the newly formed National Center for Interprofessional Practice and Education at the University of Minnesota, accelerated alignment of regulators, payers, delivery organizations, and accreditation agencies around competency-based approaches is essential to building the foundation for a reformed health professions education system supported by innovative use of technology.

In addition to the broad challenges to health professional education reform, there are also obstacles specific to the development and implementation of effective educational technology for health professional students. Some faculty may feel threatened by or not prepared for the changes associated with widespread use of educational technology and may therefore resist organizational efforts to expand online learning and reduce the number of traditional lectures. Some may resist having their lectures recorded or shared with other institutions as it puts their teaching under greater scrutiny. Faculty may also demonstrate "institutional narcissism" and the belief that only content developed at their school should be used to teach their students. This resistance stifles collaboration among schools and curtails the ability to achieve economies of scale in creating and using content.

Health professional school leaders lack evidence to make the case for greater investment in this arena. They also lack information to support decisions about which of the many and ever-changing new approaches, platforms, and technologies will best fit an organization's needs. Finally, as all health professional schools face tight budgets, the availability of funding for the investments required for these innovations is limited.

Capturing the potential efficiencies offered by these technologies will require AHCs to confront difficult questions. By reducing the constraint of lecture hall size, does this technology allow class

Table 5: Potential benefits of innovative education supported by technology

Stakeholder	Benefits
Students	■ Learner control □ When and how to learn □ Able to access knowledge at any time □ Take as much or as little time to learn material □ Opportunity to practice skills as needed □ Establish habit and skill of life-long learning ■ Enhanced, realistic visualization ■ "Learning science" approach increases likelihood that content will be mastered more efficiently and retained longer ■ Enhanced experience with learning processes ■ Access to vast repertoire of expertise ■ Ability to cover more topics in online modules than in didactic lectures ■ Shortened time to reach competency for some students and as much time as needed for other students ■ Performance tracked over time so that able to demonstrate competency (shift from "time in chair" to attainment of milestones)
Faculty	■ Increased engagement and satisfaction through greater interaction with students and opportunity for continuous innovation ■ Increased awareness of concepts and ideas that learners find difficult to master ■ Ability to identify specific learning needs of individual students ■ Iterative improvement in content and teaching methodologies ■ Ease of updating content and refining pedagogical methods ■ Reduced time delivering repeated lectures increases time available for more intellectually meaningful educational and scholarly initiatives
Institution	■ Increased ability to adapt curriculum to societal needs ■ Increased nimbleness in making curricular changes ■ Enhanced collaboration and knowledge sharing within and among organizations ■ Reduced risk to patients through use of safe, controlled environments for teaching skills ■ Increased transparency and accountability regarding the quality and cost outcomes of the education experience ■ Documentation of learner behavior and outcomes is built into the system and can be used to improve processes ■ Increased ability to meet the needs of nontraditional students with other responsibilities, which may increase diversity of the student population

Table 5, continued

Stakeholder	Benefits
Institution	■ Increased capacity to do the following: □ Educate more health professional students without replicating all costs □ Shorten time (and potentially reduce costs) for some students to achieve competency and complete training ■ Enhanced resources and new economies of scale ■ Increased capacity of existing physical plant and potential to reduce capital needed for new facilities ■ Optimized faculty time via reduced repetitive lecture demands and increased time available for mentoring, educational innovation, focus on humanism and professionalism, communication skills, and scholarly contributions ■ Decreased logistical problems of inter-professional education ■ Increased capacity to assess and analyze what is being taught and to manage curriculum ■ Increased alignment with expectations of 21st century students (Will use of educational technology become a way students differentiate among health professional schools?)
Society	■ Health professionals better prepared to meet societal needs (enhancing the quality of patient, family, and community care while making better use of finite resources) ■ Public resources for teaching health professionals are optimized

sizes to be expanded so that costs per students are reduced? If schools are sharing online lectures, are fewer or greater numbers of faculty or subgroups of faculty (e.g., tenure track) needed? Do schools need faculty with a different skill set who are capable of developing and using online approaches and facilitating interactive learning experiences rather than offering traditional lectures? If the teaching faculty of an institution changes shape over time, how will the patient care and research missions be impacted? Will research related to the educational enterprise receive increased recognition? AHCs will be well served to begin contemplating such issues as part of their strategic planning so that they have time to implement anticipated shifts over time (e.g., implement changes as hiring opportunities emerge).

Enablers

Enablers that will support and accelerate diffusion of educational technology among health professional schools fall into two broad categories—institutional enablers and national/collaborative enablers.

Institutional enablers include the following:

- A clear statement of where the institution is headed with educational process innovations and greater use of education technologies (including online learning), why the institution is making greater investment in these technologies, and how expected benefits will be achieved
- An organizational culture that embraces collaboration, focuses on competency-based education, encourages breakthrough thinking, and is student- (rather than faculty) and ultimately patient- and outcomes-centered

Table 6: Obstacles

Current learning state	Future learning state
Rigid hierarchy	Flexible hierarchy
Individual expertise and autonomy are valued	Team-based learning is valued anticipating team-based clinical care ■ Team-based expertise ■ Individual roles requiring definition ■ Competency requirements defined by the role ■ Learning content requirements defined by the role
Learning is content oriented	Learning is content and competency oriented ■ Simulation used for competency learning and assessment
Inconsistent emphasis on professionalism	Faculty time devoted to professionalism with an understanding of how health delivery metrics are influenced by professional behaviors (HCAPs, CGCAPs, engagement tools such as Gallup)
Inadequate focus on EHR technology	Emphasis on the role of EHR & informatics in tracking "pay-for-value" reimbursement metrics
Inadequate focus on benchmarking	Understanding how quality, safety, service benchmarks for individual patients and populations of patients, physicians, and care teams, are used to improve clinical processes and outcomes
Faculty-centered ■ Time on task proxy to knowledge acquisition	Student/resident/physician-centered ■ Variable time to knowledge acquisition ■ Competency-based

- Clinical and academic missions and incentives that are aligned with a new paradigm for health professions education and practice accompanied by shared accountability across the AHC for making needed changes
- Credible faculty champions who can share experiences and knowledge with other faculty
- Faculty who are supported in the transition through investments (i.e., time and resources) to develop new skills
- Technological and pedagogical resources, including expertise and technical infrastructure, which are adequately funded and developed to keep pace with anticipated changes.

National/collaborative enablers include the following:

- A shared compelling vision for health professional education that is embraced by the health care community
- Standards for sharing educational content and tracking students across settings and time
- Platforms for sharing content
- Communities of practice that share best practices
- Organizations that are willing to share content (either for free or via licensing)
- A research agenda to fill key gaps in our understanding of the effectiveness of technologies and approaches

In addition to the emerging shared learning management platforms (e.g., Coursera, Udacity) and open source content (OpenCourseware), several collaborative enablers focused on health professions education are already in place.

The **Association of American Medical Colleges (AAMC) Medical Education Research Certificate (MERC) Program** (https://www.aamc.org/members/gea/merc/) "is intended to

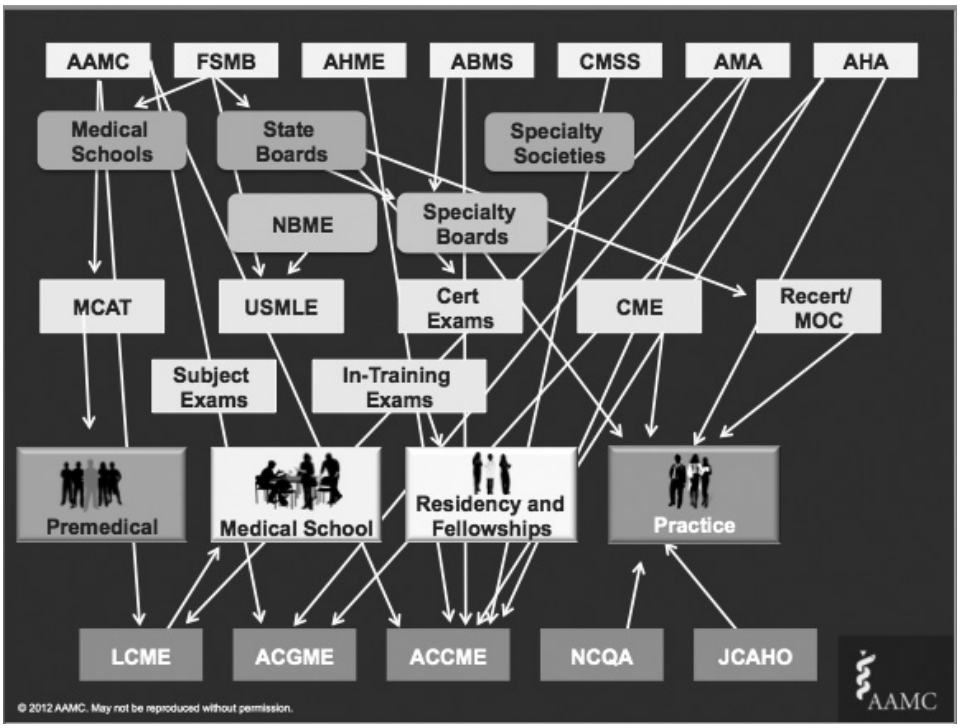
provide the knowledge necessary to understand the purposes and processes of medical education research, to become informed consumers of the medical education research literature, and to be effective collaborators in medical education research." The courses are targeted for clinicians and other educators who desire to learn research skills that will enable collaborative participation in medical education research projects. Strengthening medical education research skills among faculty will increase an institution's ability to evaluate internal educational technology activities and to participate in multi-institution studies.

The **Institute for Innovative Technology in Medical Education (iInTIME)** (http://www.i-intime.org/) was established in 2006 to advance medical education through the collaborative development, maintenance, and research of innovative and comprehensive computer-assisted instruction programs. Through MedU, iInTIME provides a platform for sharing and accessing virtual patient cases and other medical education programs for third-year students across a range of disciplines (pediatrics, radiology, genetics, internal medicine, family medicine, and surgery). In addition to providing a platform for sharing content, iInTIME offers authoring software and training resources to support medical educators in the development of virtual patient cases. Further, "the broad use of MedU cases fosters an active cross-disciplinary community of medical educators."

The **MedBiquitous Consortium** (http://www.medbiq.org/) creates technology standards that allow organizations to exchange educational content and track learner activities and profiles. These standards support flow of data to track professional achievement and share learning resources. MedBiquitous emphasizes lifelong learning and continuous improvement by practitioners as it seeks to enable better patient outcomes.

MedEdPortal (https://www.mededportal.org/) is a clearinghouse for high-quality, peer-reviewed health education tools. The free service is provided by the AAMC in partnership with the American Dental Association. The mission of MedEdPortal is to promote "educational scholarship and collaboration by facilitating the open exchange of peer-reviewed health education teaching and assessment resources." More than 10,000 national

Figure 3



and international health education institutions in 195 countries are accessing and utilizing MedEdPortal content. Users include schools of medicine, dentistry, osteopathy, nursing, pharmacy, and public health, as well as the general public.

The **National Center for Interprofessional Practice and Education** (http://www.ahceducation.umn.edu/nexus-ipe/) was launched in September 2012 at the University of Minnesota with a five-year funding commitment from the Health Resources and Services Administration (HRSA) and four leading foundations. This public-private partnership will identify ways to "improve health, enhance patient care, and control costs through integrating interprofessional practice and education." The center is focused on five core domains: leadership; collaborative practice and health system transformation; education and training; research, evaluation and scholarship; and innovative and novel models.

OPENPediatrics (http://www.openpediatrics.org/) is an open self-directed learning platform that promotes sharing of knowledge about care of ill children through three key functions—information on demand, social networking capability, and education on general principles and optimal practice in pediatric care. This beta test site is aimed at the global community, but once broadly available the learning modules on this site could also serve health professional students and practitioners in the U.S. Further, this approach could be adopted by other specialties.

Emerging Research Agenda

The widespread adoption of information technologies has led to a corresponding growth in the development of sophisticated, realistic teaching resources. However, our understanding of how these resources might best be incorporated into the curriculum is inadequate, as advances in what could be created often outpace our ability to understand how they should be developed or used.[43]

What do we know about the effectiveness of online learning or computer-aided instruction for health professions students? In general, researchers have found that these methodologies are more effective than no intervention (i.e., no instruction) and slightly more effective than or comparable to traditional teaching approaches.[35] One meta-analysis of studies on Internet-based instruction involving health professions learners concluded that (1) compared with no intervention, online learning (Internet-based learning, or IBL) yielded large positive effects and that Internet-based instruction was effective across a variety of learners, topics, and contexts; (2) differences in effects compared with those of non-Internet instructional methods were generally small; and (3) some methods of IBL may be more effective than others.[61] This study did not, however, find evidence on which to base guidelines for future implementations of IBL. A subsequent study by the same researchers focused on direct comparisons of one IBL intervention for health professionals against another.[62] Researchers identified a "modest number" of studies for analysis and therefore qualified their conclusions in terms of "highlighting promising areas for future research." They concluded that interactivity, practice exercises, repetition, and feedback improve learning outcomes and that interactivity, online discussion, and audio improve satisfaction in IBL for health professionals.

Perhaps most important in these and other early studies is the emerging research agenda for this domain. The research agenda would include, but is not limited to the following:

- Do these technologies impact the applied knowledge and skills of health professional students and contribute to the continued refinement of competencies?
- Which of these technologies are most effective overall, and does effectiveness vary across types of learners, stages of learning, and various content areas?
- When should online learning or other educational technologies (e.g., virtual patients, spaced-education games, apps) be used?
- How can online learning be effectively implemented? Under what conditions could online learning be used exclusively to achieve student competency? When does it best serve to augment small-group learning?

- How do skills developed on simulators transfer to patients?
- What is the cost-benefit of these technologies? Do these technologies yield savings in the educational process within individual institutions or across groups of institutions? Do they improve quality of education? Is there a positive return on investment?
- Can the effective use of these educational approaches and technologies be linked to improved patient outcomes?

As a first step, researchers need to develop shared frameworks for research, consistent definitions of interventions and comparison interventions, and common outcome measures.[63] Working from shared frameworks, interventions, and outcomes will permit replication across learner groups and different educational objectives. Further, as more institutions begin to use shared learning platforms, the data pool for analysis will grow considerably and enable larger, multi-institution studies.

Recommendations

The Blue Ridge Group concludes that innovative use of educational technologies, including but not limited to online learning, offers the potential to make progress toward specific elements of the vision for enhanced health professions education. These technologies can

- Facilitate greater flexibility for several dimensions of the health professional educational enterprise
- Create a wide variety of practice opportunities for students
- Enhance quality and increase efficiency of teaching processes
- Enable measurement and tracking of costs and outcomes of educational processes
- Capture and track student performance

To take advantage of these technologies, both institutional and national capacity in the form of a technological infrastructure and technical and pedagogic expertise need to be strengthened. To achieve desired efficiencies, core content must be identified, platforms for sharing content must be adopted, and institutional hubris must be overcome. Greater investment at the institutional and national levels is needed to support diffusion and evaluation of the technologies. Institutional and national leaders need to increase awareness of the benefits of these tools and associated changes in teaching processes, but they should also be cognizant of the limitations of the technologies under consideration. AHC and health professional school leaders should also understand that while there is considerable potential in sharing content among institutions, how that content will be used will vary because of differing needs and foci of AHCs and schools. That is, one size will not fit all.

Institutional initiatives

AHCs have varying levels of experience with educational technologies. Yet virtually all AHCs have implemented clinical information systems and can draw upon that experience as they seek to increase use of educational technologies as a means of improving quality and efficiency of education processes. Just as with clinical information systems, AHCs and health professional schools should follow a structured process for expanding use of educational technologies. They should

- Conduct a needs analysis that will serve as the basis for selecting which technologies and approaches to adopt
- Develop business and implementation plans
- Expand institutional capacity to support technological and pedagogic innovations
- Evaluate effectiveness of implemented technology and approaches to determine which should be continued, modified, or eliminated and share results with the broader community

Needs analysis—As a first step, AHCs and health professional schools should do the following:

- Identify organizational needs that can be met through innovative use of education technologies
- Define the value that the institution seeks to capture through increased use of educational technologies
- Inventory existing initiatives and resources within their schools and across the university including faculty, staff, students, and partners already engaged in innovative approaches as well

as investments in technology already in place, such as use of EHRs for teaching and research
- Increase organizational knowledge of external resources that can be adopted
- Assess whether existing learning management systems can support evolving needs (e.g., greater use of online lectures, incorporating content from other institutions, sharing content with other institutions, creating student and faculty portfolios)
- Identify the approaches most relevant for their institutional situation, student needs, and mission

Business and implementation plans—In developing the business plan, AHCs and health professional schools should do the following:
- Articulate the business model for expanded use of educational technologies within the schools and across the AHC (e.g., does the institution seek to achieve efficiencies to offset costs, improve quality for same costs, expand throughput, capture revenues from new sources)
- Identify the level and mix of resources needed to capitalize on the technologies and innovations (i.e., financial, human, technological) and consider whether the needed faculty skill set will evolve over time
- Identify funding sources
- Determine the optimal mix of internal development, institutional partnering, and outsourced development
- Determine which platforms for sharing content are optimal

In developing an implementation plan, AHCs and health professional schools should do the following:
- Determine how they can build on existing internal and external resources
- Identify ways to encourage a climate of innovation and breakthrough thinking (e.g., allocate funding for pilots that test novel approaches to education technology)
- Identify champions and recognize efforts already under way through existing communication channels
- Establish mechanisms to bridge existing "islands of innovation" (e.g., hold a university-wide conference where faculty, staff, and students can share their work, fund joint projects that cross departments or disciplines)
- Set specific organizational goals, develop clear expectations for faculty and staff, and align performance incentives to desired outcomes

Expand institutional capacity—To expand institutional capacity to develop and apply educational technologies that meet organizational needs, AHCs and health professional schools should do the following:
- Allocate time and provide training opportunities for faculty to develop skills and gain experience in developing and using new educational technologies and approaches (e.g., developing online learning modules and leading more interactive face-to-face sessions)
- Establish support services that provide educational design/pedagogic expertise and technical expertise (e.g., app development, copyright clearance and intellectual property for content that is to be shared)
- Upgrade or replace the existing infrastructure to achieve a robust learning management system, authoring tools, student portfolios, faculty portfolios, ability to use content developed elsewhere, and ability to share content with other institutions
- Encourage development of learning communities or communities of practice by region, professions, common interests, or other delineators to enable and accelerate knowledge sharing

Evaluate effectiveness—To provide guidance on future educational technology initiatives, AHCs and health professional schools should do the following:
- Require that all educational technology initiatives funded internally include an evaluation that measures effectiveness for learners and the degree to which organizational goals are met
- Support faculty training in health professions education research
- Encourage participation in multi-institution studies

National initiatives

The Blue Ridge Group identified the following actions to accelerate diffusion of education technology among AHCs and health professional

schools with the goal of improving the quality and efficiency of educational processes and ultimately strengthening the health professions workforce:

- As a professional community, we must insist that accrediting, licensing, and certifying agencies align their processes to support the innovations described in this report as well as the broader changes needed (e.g., movement toward competency-based education) for transformation of health professions education.
- AHCs and health professional school leaders and representatives of licensing and certifying agencies should identify "commodity" curriculum components and encourage adoption as a standardized core across institutions to gain economies of scale and allow faculty to focus on individualized and group learning experiences as a way to improve quality and efficiency in the learning process.
- AHC leaders and national professional organizations should increase awareness regarding the potential for technology to transform health professions education, including impact on quality, cost, and outcomes of education.
- AHC leaders and national professional organizations should create a national collaborative to accelerate and coordinate development of a framework and tools for assessment and dissemination of innovative educational approaches (including use of technology) designed to improve the quality and efficiency of health professions education.

Collaboration will be key to achieving desired outcomes. The full benefits of these technologies and approaches will be achieved only if institutions come together to do the following:

- Share best content
- Ensure that content is inter-operable
- Share best practices and experience
- Rigorously assess impact of technology and innovations and provide feedback on quality of content
- Identify opportunities for reducing costs by working together

Specific goals for the collaborative would include creating a community of users and developers, identifying and publicizing existing resources that can help facilitate advancement of these initiatives (e.g., MedEdPortal), stimulating action on development of core and commodity curriculum components, achieving consensus on research priorities, establishing pilots to test effectiveness, expanding awareness and creating a sense of urgency, and developing tools that organizations can use as they consider and implement educational technologies.

Conclusion

Most new movements start this way: hundreds or thousands of individuals and groups, working in different fields and different locations, start thinking about change using a common language, without necessarily recognizing those shared values. You just start following your own vector, propelled along by people in your immediate vicinity. And then one day, you look up and realize that all those individual trajectories have turned into a wave. (Steven Johnson)[64]

The shortcomings in health professions education and the growing wave of online learning create unprecedented challenges and opportunities for AHCs and health professional schools. Pioneering institutions are highlighting how educational technologies and approaches based on cognitive science can be used to address health professions education deficits and offer greater value to students. Shared learning management platforms offer new ways for schools to share content, assess effectiveness of various educational tools, and reduce costs. These technologies support innovation and enable collaboration among schools and across disciplines. To maximize the impact of online learning technologies, AHC leaders need to articulate a new vision, pool resources, confront structural barriers, and establish a mechanism for sharing content and best practices.

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About the Blue Ridge Academic Health Group

The Blue Ridge Academic Health Group (Blue Ridge Group) studies and reports on issues of fundamental importance to improving the health of the nation and our health care system and enhancing the ability of the academic health center (AHC) to sustain progress in health and health care through research—both basic and applied—and health professional education. In 16 previous reports, the Blue Ridge Group has sought to provide guidance to AHCs on a range of critical issues. Previous reports identified ways to foster a value-driven, learning health care system for our nation; enhance leadership and knowledge-management capabilities; aid in the transformation from a paper-based to a computer-based world; and address cultural and organizational barriers to professional, staff, and institutional success while improving the education of physicians and other health professionals.

Reports also focused on updating the context of medical professionalism to address issues of conflict of interest, particularly in the relationship between academic health professionals and institutions and their private sector partners and sponsors; quality and safety; and improved care processes and innovation through the use of informatics. One key report explored the social determinants of health and how AHCs could reshape themselves to address this critical dimension of improving health. The group also issued a policy proposal that envisioned a new national infrastructure to assure ongoing health care reform, calling for a United States Health Board; identified opportunities and the most critical challenges for AHCs and their partners as the Accountable Care Act (ACA) was implemented and examined ways in which AHCs could leverage their unique characteristics and capabilities through the ACA to improve health care, research, and training systems.

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