▲ Technologies for Interprofessional Education: The Interprofessional Education-distributed "e-Classroom-of-the-Future"

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Communications strategies are central to the planning and execution of interprofessional education (IPE) programs. The diversity of telecommunications-based tools and platforms available for IPE is rapidly expanding. Each tool and platform has a potentially important role to play. The selection, testing, and embedding of tools, such as social networking platforms, within education programs can be very challenging. The goal was to create, in Phoenix, a "command-and-control" video conferencing center (the "T-Health Amphitheater" or "Telehealth Amphitheater") in which tele-consultation patients, located physically at one of the affiliated tele-clinics around the state, could be presented electronically to interprofessional teams of faculty members from the University of Arizona Colleges of Medicine, Nursing, Pharmacy, and Public Health, as well as those from the allied health colleges of other universities in Arizona, for interprofessional team training in a virtual classroom setting. The T-Health video conferencing facility was designed and built. Early assessments show that its novel learning environment is student- and faculty-friendly. T-Health Amphitheater's pair of innovative visible social networking platforms (eStacks™ and eSwaps™) may help break down some of the traditional communications barriers encountered in healthcare IPE and medical practices. J Allied Health 2010; 39(3 pt 2):238–245.

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ONLINE TECHNOLOGICAL ADVANCES have enabled diversification of methods for acquiring and applying knowledge. Online education is now firmly established as a viable alternative to traditional classroom pedagogy, enabling knowledge acquisition to occur asynchronously in time and space. This is often viewed as emphasizing individuality in learning, but it can also be seen as a means of facilitating interconnectivity across professional disciplines. Empowered by social networking tools, health career students should be able to maximize their dialogue about healthcare principles beyond the foundations of anatomy, physiology, and pathology to such topics as ethical and professional issues.[1,2] Handheld electronic devices already make convenient real-time idea exchanges outside of the face-to-face classroom encounters that are often difficult to orchestrate between disparate curricular schedules. For example, the "new" nursing student, comfortable with diverse "friends" (e.g., a Facebook™ interaction), may be more at ease in conversations with medical students about a challenging clinical problem than in the past, based on an expanded, egalitarian mindset.

An attribute of today's learner is active immersion in constructing reality from available sources. Increased creativity in MySpace.com™, a well-known social network platform, enables a more flexible approach for students to customize an educational construct with formal course materials, Internet-identified scholarly literature, Google™ images, and simulated encounters. The richness of such a learning tapestry,

combining content, commentary, and inquiry, is further increased when student teams share contributory roles.

Current financial challenges on institutions of higher education are also driving the need for new educational paradigms. Decreased endowments for private schools and state budget cuts for public schools have limited new "bricks and mortar" construction, faculty hiring, and student enrollment for conventional university training. Modern telecommunications make possible higher enrollment and facilitated faculty coverage without the need for new buildings or increased faculty hires. Work on student team projects is possible at any time, rather than being confined to university classroom hours of operation. Faculty office hours can be expanded to permit more timely dialogue between learner and teacher.

Because of the shortened interval between technology-facilitated educational experimentation and evaluations of outcomes, which is made possible by modern telecommunications, the potential is increased for rapid diffusion of successful best practices in innovative educational approaches. The potential exists for standardized "learning portfolios" connecting educational strategies, "skill acquisition and [improved] patient care."[3]

A major challenge to healthcare planners and educators is to manage the diffusion of new communications technologies into healthcare education programs. Although there is a shared sense that new electronic technologies could change the playing field for healthcare education, the potential uses, efficiencies, advantages, and drawbacks of telecommunications-based platforms, such as social networking platforms, in facilitating complex interactions between students and practitioners of the various healthcare professions remain to be critically examined.[4,5] Planners of IPE programs will be increasingly at the mercy of technology innovators and market forces as new technologies burst onto the scene. The life cycles of telecommunications-enabled technologies may also get shorter and shorter.

This paper describes the features and implementation of a first-of-a-kind amphitheater (the T-Health Amphitheater ["Telehealth Amphitheater"]) that was designed to serve as the hub for a distributed IPE learning center. The facility was designed and constructed between 2004 and 2008. It was brought online as a video conferencing/distance-learning center in late 2008, and formally dedicated by University of Arizona President Robert N. Shelton, PhD, Arizona State Senate President Robert "Bob" Burns, and the founding Director of the Arizona Telemedicine Program, Ronald S. Weinstein, MD, on October 23, 2009. It is now used for a regularly scheduled course for high school students interested in healthcare careers. This will be extended to health professions students in 2011.

Design and Implementation of the T-Health Amphitheater

Design, testing, and implementation of regularly scheduled usage of the T-Health Amphitheater was a 6-year process. As a historical footnote, some of today's most popular visual social networking platforms, such as Facebook™, were under development around the same time this project began. It is noteworthy that our use of the term "visible social networking platform" is different from today's common usage of the term. We use the term to describe an environment in which interactions are in real-time (dynamic) and are designed to break down human communications barriers. A previous publication described the plans to construct a T-Health Amphitheater.[6] This paper describes the completion of the T-Health Amphitheater and its innovations as a state-of-the-art e-classroom environment.[7]

The construction of the T-Health Auditorium was a component of a historic building rennovation program in downtown Phoenix. The T-Health Amphitheater was retrofitted into an abandoned, century-old high school auditorium building. The 1600-ft^2 space includes a dedicated control room, a HIPAA-compliant staging area, and a state-of-the-art, three-tiered classroom with 17 student desks. Each desk is equipped with a microphone, a headset, and a touch screen panel. Using a Tandberg (Tandberg Corp., Oslo, Norway) video conferencing system and a video wall consisting of twelve 50-inch Toshiba DLP video wall displays (Toshiba Corp., Tokyo, Japan), this virtual teleconferencing hub enables local participants, distance learners, and faculty off-campus to participate in joint real-time learning sessions.

A custom-designed graphic user interface, displayed on a Crestron audio–visual control system panel (Crestron Electronics Inc., Rockleigh, NJ), allows the local facilitators to control all local and remote functions of the T-Health Amphitheater. The Crestron control system, managed with touch panels and with custom programmed user presentation layers, is utilized to integrate and streamline control of the numerous sources and distribution points associated with the complex configuration of audio, video, and video-conferencing systems. Video wall multimedia display functions are managed with a Jupiter controller (Jupiter Systems, Hayward, CA). Audio-Visual Resources, Inc. (Phoenix, AZ) was the system integrator.

T-Health Amphitheater Video Cube Wall

Figure 1 schematically shows multi-site interprofessional team training using a statewide "virtual campus" linked to University of Arizona classrooms and dozens of Arizona Telemedicine Program (ATP)-affiliated clinics located around Arizona. The T-Health Amphitheater's 5 × 20-ft video wall (using a 2 × 6 video cube array) displays participating healthcare profession faculty members (left quad), a telemedicine clinic (center, displayed on a drop down screen using an LCD projector), and medical, nursing, pharmacy, and public health students (right quad) in this example. All of the participants can interact in real-time. In other preformatted configurations of the T-Health Amphitheater, the center drop-down screen retracts, revealing the center video

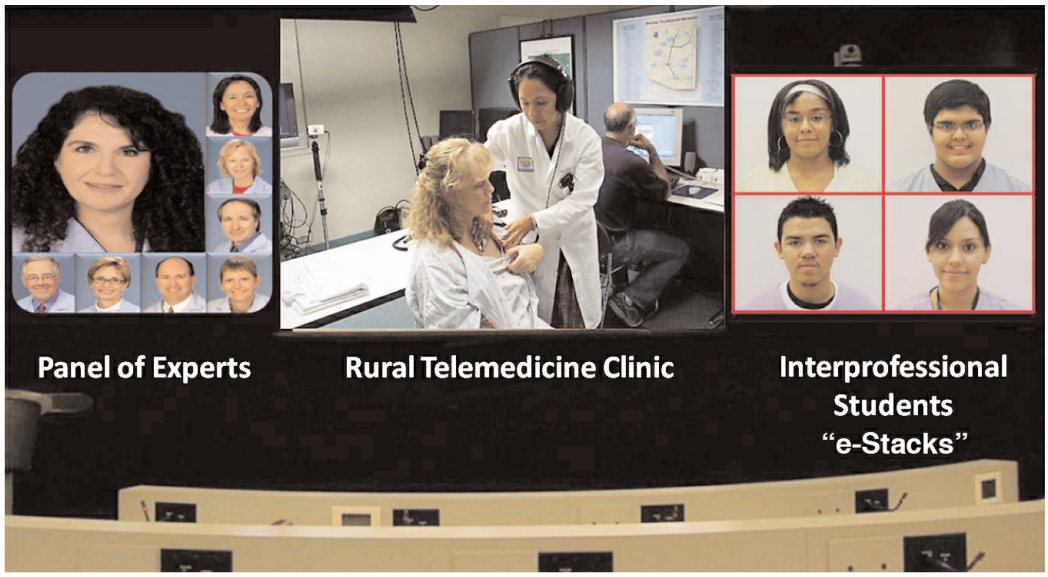

FIGURE 1. Layout of the T-Health Amphitheater Video Wall (*simulation*). ***Left***, Conceptual rendering of a panel of 8 off-campus healthcare faculty subspecialty medical experts participating in the work-up of a telemedicine patient at a remote clinic (center drop down screen). The eight off-site faculty members are equipped with Internet-linked Tandberg T-150 video conferencing units. They can be physically located in their offices, their laboratories, or in remote clinical facilities, linked in with a Tandberg T-150 video conferencing unit. The "speaking" expert appears in the large area of the video screen (left) until the *next* expert, residing temporarily as one of the thumbnail video icons at the perimeter of the display, begins to speak, then populating the larger domain on the video display (left). ***Center***, Telemedicine patient sharing her medical history simultaneously with her on-site physician and remotely to the panel of experts (left) plus the interprofessional group of students (right), including a medical student, a nursing student, a pharmacy student and a public health student, each displayed in one corner of the quad video display (right). ***Right***, Interprofessional Student Teams: Each quadrant accommodates an "e-Stack™" of students from a single professional track, each dialing in over the Internet from their off-campus location. Students and faculty members, physically present in the T-Health Amphitheater, can electronically insert themselves into their professional education track-specific quadrant. For example, nursing students either off-site or physically present in the T-Health Amphitheater will always appear in the upper right hand corner of this quad, at the University of Arizona.

cube quad (2 × 2 video cube array) in the center of the video wall. At the bottom of this figure, aspects of tiers of student benches/desks, with incorporated small touch screens (shown as black blank screens), are seen.

"e-Stacks™" Visible Social Network Application

The visible social network application e-Stacks™, a concept developed by the Arizona Telemedicine Program design team, was created to provide an engaging learning experience for IPE health profession students. The T-Health Institute, in Phoenix, is a division of the Arizona Telemedicine Program headquartered in Tucson, Arizona. By instituting specific career track domains on a video quad display, career-track parity is assured in interprofessional student group discussions. This video solution addresses the problem of the hierarchical dominance of medical students during IPE group discussions.

Implementation of the e-Stacks™ application required the use of multiple video conferencing CODECs and a custom-built video conferencing bridge. One multi-point-enabled CODEC per remote stack (i.e., a queue of medical students, a queue of nursing students in a second video stack, etc.) was required. Four stacks are included in the T-Health Amphitheater design to accommodate multiple remote participants from each of four different health professions per session (Fig. 2). To provide an even higher level of flexibility, one of the e-Stacks™ can be comprised of students who are physically present in the T-Health Amphitheater. A multipoint video conferencing connection was required to bridge the e-Stacks™ together into a cohesive interdisciplinary group that could communicate with a panel of subject matter experts (see Fig. 1, with the "Expert Panel" displayed on the left and the e-Stack of students on the right side of the video wall). The faculty content experts can be present locally, in the T-Health Amphitheater, or remotely linked in from a distant location by video conferencing, typically using a Tandberg T-150 portable video conferencing unit, or similar appliance, deployed in their office.

"e-Swaps™" Visible Social Network Application

The other new visible social network application, e-Swaps™, a concept also developed by the T-Health Institute's design team, provides a means for creating and shuffling student participant profiles (displayed as quads, but comprised of "e-Stacks™") on-the-fly (Fig. 3). The session

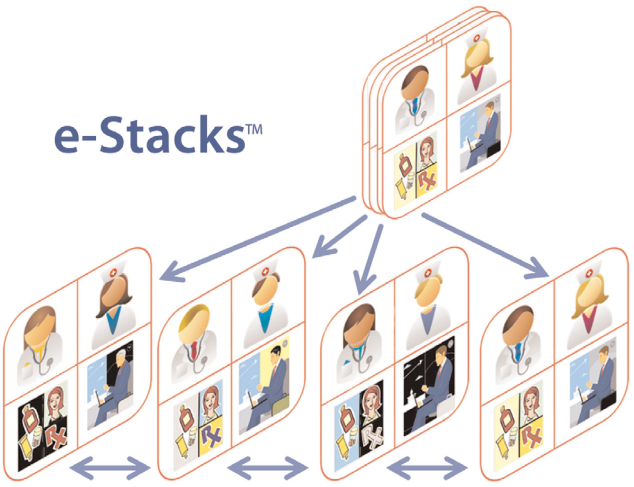

FIGURE 2. e-Stacks™ application. Illustrations show iconic representations of stacks of medical students *(upper left)*, nursing students *(upper right)*, pharmacy students *(lower left)*, and public health students *(lower right)*. ***Top Row***, four layers of the stacks. ***Bottom Row***, "exploded" version of the electronic stacks of students. ***Below***, Students can take a portable, "in a suitcase" video conferencing unit (i.e., Tandberg T-150) with them for off-campus rural rotations, and link themselves back to the T-Health Amphitheater in Phoenix by broadband Internet. In this simulation, video "stacks" of medical, nursing, pharmacy, and public health students, are queued up behind their college-specific classmates "on-screen." Students in the individual queues come to the foreground and then visible in their quadrant of the video display by voice-activation. However, all of the students in e-Stacks™ space can participate in the audio component of the conference. Off-site students see (on their T-150 displays) the content directed to them by the sesson monitor. Thus, although only four students are displayed in the video display quad (right) at one time, many additional off-site students can join the interprofessional training session by video conferencing, remotely linking to their career-track specific video conference queue.

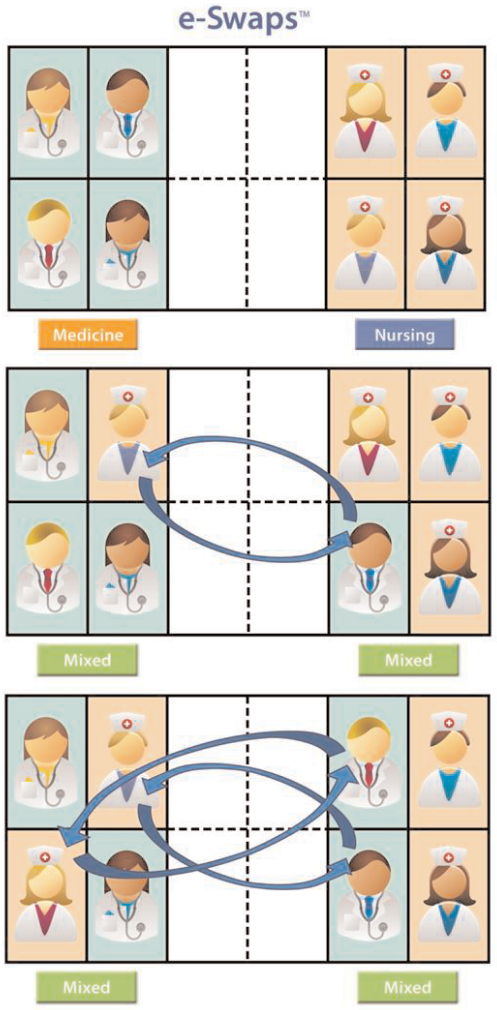

FIGURE 3. e-Swaps™ application. Schematic of the T-Health Amphitheater's 2 × 6 video cube wall shows how two e-groups in quads, i.e., a group of four medical students on the left, and four nursing students on the right *(top figure)*, can be electronically reconfigured and reconstituted into interprofessional teams "on the fly." The students can be either on-campus or off-campus. The result is an admixture of medical students and nursing students in the two individual learning groups *(See middle and bottom figures for examples of single swaps and double swaps.)*

moderator initiates the individual student transfer (or student e-Stack™ transfer if more than one student is queued within a single column of the quad, electronically one behind the other) between the right and left quad groups, which are displayed live on the T-Health Amphitheater video wall when the system is configured in the e-Swaps™ mode. When participants are transferred from one group to another, their audio channels automatically relocate with them and are mixed into the new host audio channel.

The e-Swaps™, as illustrated in Figure 3, are managed by the classroom facilitator in the T-Health Amphitheater using the Crestron touch panel at the podium. In a typical session, the student groups discuss and analyze patient vignettes and engage in problem solving. Students can compare their experiences working in a "single profession" group (Fig. 3, top) or a "multiprofessional" group (Fig. 3, bottom). We envision that this e-Swaps™ video conferencing strategy will heighten student and faculty awareness of the unique content areas and perspectives of individual healthcare professions, while encouraging and leveraging these differences into a team approach for patient case management.

Push-to-Talk Feature

Push-to-talk technology is an off-the-shelf product. However, the push-to-talk microphone technology, as implemented in the T-Health Amphitheater, links video camera tracking and participant queueing, including on-screen display of a list of queued participants' names, and the capability for remote participants to also add themselves to the queue (Fig. 3). These customized features are valuable for providing a structured and effective classroom environment, either locally, or in a distance-learning configuration

FIGURE 4. Electronic queuing in the T-Health Amphitheater. High school students planning to have healthcare careers are participating in a "classroom jeopardy" exercise in the T-Health amphitheater. Using the "push-to-talk" screens at each desk, the students view "Jeopardy" questions on a drop-down screen (not shown) and electronically insert themselves into the participant queue to respond to the question (lower left and lower right). (Student names are simulated.) This customized T-Health Amphitheater was designed to reduce communication barriers among students in various healthcare professions in a shared team training classroom setting, but is providing additional popular applications.

(Fig. 4). The custom-designed queueing software has proven to be a very popular feature, even when used locally without a distant video conferencing component.

Off-Campus Remote Video Conference IPE Participants

Tandberg T-150 Portable Video Conference Systems

The Tandberg T-150 appliances are portable video conferencing units that are distributed to off-campus students and faculty, typically in a custom-designed suitcase (Fig. 5). The T-150s are 13.6-in high × 9-in wide, with an 8.4-in video screen, and weigh 3.3 lbs. Components of the portable conferencing suitcase include a Tandberg T-150, an easily assembled studio-quality lighting unit (Kühl lite 30-soft box; Table Top Studio LLC, Carpinteria, CA), and all the peripheral cabling needed to make the video conference connection.

The Tandberg T-150 plugs into a local area network (LAN) port. A computer can also be connected to the LAN via the 2-port Ethernet switch of the Tandberg T-150, enabling LAN and Internet access for both the T-150 and the computer if only a single LAN port is available. Other H.323-standard video conferencing systems can be substituted for, and are interoperable with, the Tandberg T-150 units.

Tandberg T-150 Displays of T-Health Amphitheater Video Wall Elements

Figure 6 shows various Tandberg T-150 screens, as viewed by faculty and/or students at off-campus sites. The session facilitator, at the Crestron podium in the T-Health Amphitheater, uses touch screen controls (left) to select the video content to be sent to the off-site Tandberg T-150s over the Arizona Telemedicine Program network or an alternative IP broadband linkage. Compare these displays with the T-Health Amphitheater video wall in Figure 1.

Discussion

As secondary education continues to be a widely sought-after commodity by today's youth, the consumer market has been flooded with possibilities for social networking tools, a child of Web 2.0, to be assimilated into the foundations of institutional learning. Whether these tools are self-adopted by students within the institution as a form of community or adopted by the institution administrators as formalized delivery channels, Web 2.0 has made several contributions toward changing the dynamics of the educational process.[8,9]

A recent publication defined Web 1.0 as, "the web version of the Three R's: Reading, Receiving, and Researching."[9] Web 1.0 sounds much like the current formalized process of delivering an education, in which an educator instructs and directs the learning of students within a physical classroom via predetermined materials, activities, and guided research. As Web 2.0 tools, specifically social and educational networking tools, become more available and accessible, educators will either formally adopt these tools to augment learning or will simply encourage that these tools be adopted by pupils as a better method for communication regarding learning.

What is the size of the "visible social networking" market today? Facebook™ is a widely-adopted social networking tool.[10] Boasting more than 500 million active users, it has evolved into something more complex than a social network. It has become a platform for all kinds of activities, be they social, educational, or commercial. To assess the magnitude of its effect, a few simple queries were executed on the Facebook™ site. For example, a simple search using the term "University of Arizona" yielded approximately 21,000 page results. Since these results are derived from an indexing process that observes all text

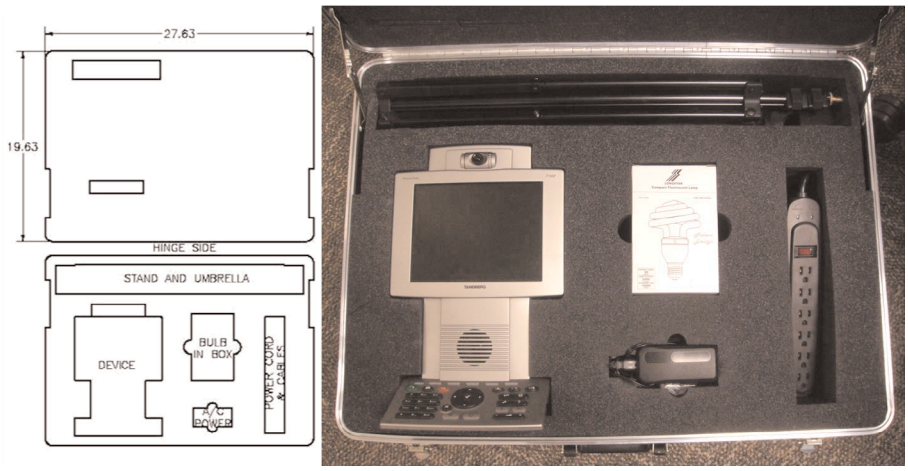

FIGURE 5. Diagram of custom-designed suitcase (*left*) and the actual prototype of the custom suitcase containing the video conferencing device (Tandberg T-150), studio quality lighting, and all of the peripheral items to make the video conferencing connection.

recorded, this could mean that a respective user has commented about the University of Arizona, a page has been created by an academic department at the University of Arizona, or a user has joined a group that is affiliated with the University of Arizona. A more pointed search, "University of Arizona College of Medicine," yields only 12 results that have a text-based relation. The result set is comprised of user-created groups that are part of a future graduating class, a group dedicated to singles attending the College of Medicine, and finally a group of Christian students attending the College of Medicine. While these results sets may not seem purely educational, they support the argument which states that there is an inherent environment within social networking that is heavily affiliated with these educational institutions.

A June 2009 post on a well-known online education web host "OnlineColleges.net" outlined 50 ways to teach in the college classroom with Twitter™, a social networking tool that allows users to make brief, 140 character-long posts also known as "micro blogs." The curious question about a tool set like Twitter™ is usually the elephant in the room at faculty curriculum meetings: "How can you teach with only 140 characters of text?" Here are a few ways identified: get to know your classmates, collaborate on projects, brainstorm, take a poll, follow your occupation, follow mentors. Other examples can be referenced at www.onlinecolleges. net.[11]

We have experience with Twitter™. The Arizona Telemedicine Program, in collaboration with the Mel and Enid Zuckerman College of Public Health at the University of Arizona and the Arizona State University School of Nursing, sponsors a popular K–12 teachers program, called "Teach Tec." This 2-day course instructs primary and secondary school teachers in how to incorporate advanced, customized, hands-on electronic technologies into their courses. The Teach Tec Course has effectively integrated Twitter™ into their video conferenced multi-site program. Evaluations by the K–12 teachers taking the Teach Tech course have rated it excellent (Barker G, personal communication, 2010).

The aforementioned tools are not meant to replace the conventional textbook method of delivering curriculum; rather, they are utilized to augment and enhance this process with more accessible and identifiable methods for communication. As institutions start to develop and implement methods of distance education provisioning, the methods utilized to facilitate learning will need to be agile enough to respond to new ideas and concepts related to the curriculum being delivered. At the same time, it is important to understand the responsibility of using contemporary technologies in education settings. Cultural norms must be considered and techno-etiquette "rules of engagement" need to be established to ensure a respectful and value-added learning enviroment.

It is apparent that the movement for social networks and Web 2.0 as a whole has started in a widely informal fashion based on the behaviors observed. A recent report by the National Association for College Admission Counseling observed interesting findings that more than half (53%) of colleges monitor social media for "buzz" about their institution. A majority of colleges maintain a presence in social media, 33% of colleges maintain a blog, 29% maintain a presence on social networking Web sites, 27% maintain electronic message or bulletin boards, 19% employ video blogging, and 14% issue podcasts. Thirty-nine percent of colleges reported using no social media technology. Eighty-eight percent of admission offices believed social media were either "somewhat" or "very" important to their future recruitment efforts. This shows that not only are students using these tools for communal learning but the toolsets are inclusive to any party that deems a social networking tool as a relevant channel for communication and information gathering.

In this paper, we use the term "visible social networking" in a novel way. Rather than showing galleries of still elec-

FIGURE 6. T-Health Amphitheater's Crestron display options, as would be viewed on the remote Tandberg T-150 video conference units by off-site faculty members (compare with Fig. 1). A representation of the T-Health Amphitheater Crestron touch-activated control screen is shown on the left. In this example, the classroom facilitator has selected "send to panel" and has four options (*left to right*): 1) send video/audio images of student e-Stacks to the expert panel members; 2) send the video/audio stream of the telemedicine clinic to the expert panel members supplied with T-150s; 3) send other content to the panel members, such as the brain mapping diagram shown on the T-150 video screen; or 4) send the eight-member expert panel members the video of the panel in which they are participants (right). Choice of the distribution option for the outgoing video content from the T-Health Amphitheater is managed by the facilitator at the amphitheater.

tonic images, we have created a highly dynamic video environment to promote socialization of students in several different educational tracks, and to encourage interprofessional faculty to "team teach."

Our perceived need to develop a specialized video conferencing hub for interprofessional education grew out of our growing awarness of some of the disparities among various groups of healthcare professionals, including differences in average age, education, and career goals. We were influenced by both our own classroom observations, which were not particularly unique, and our unusual experiences being involved in the creation and management of a large telemedicine program. In describing what we refer to as an "e-Classroom of the Future," we acknowledge the obvious, that nobody can predict how students will be learning in the future, even a few years from now. Nor can predictions be made, with any certainty, of the future job descriptions for healthcare professionals. Speculations on these matters have a short life cycle these days.

The influences of our experiences with telemedicine on the design of the T-Health Amphitheater were considerable.

The Arizona Telemedicine Program (ATP) was one of the first statewide telemedicine programs to implement a sustainable business model. Today, 55 healthcare organizations are members of this collaborative.[12] The ATP engineering team built out its own broadband telecommunications network, which currently links 150 sites in 70 communities. Patient services have been facilitated in over 60 medical and nursing specialties. To date, over 1,000,000 patients have received telehealth services facilitated over the ATP network.

The ATP has been a leader in innovation in healthcare education, supporting a broad spectrum of activities ranging from College of Public Health masters and doctoral degree courses to innovative K-12 training programs for teachers. The ATP has won seven national awards for its innovations in education and its staff includes Lifetime Teaching Award winners from the University of Arizona. At the University of Arizona, many innovations in developing next-generation education tools have come from ATP staff and faculty (see www.telemedicine.arizona.edu).

ATP staff have carried out a number of studies relevant to the current and planned activities of the T-Health Amphitheater. We have shown that patients can be effectively serviced by interprofessional teams using telemedicine technologies.[13–15] Interprofessional groups of students can participate in these encounters as clinical learning experiences. In studies of the comparative effectiveness of various video conferencing formats, we discovered that video conferencing increases interactions and socializaton of individuals in hierarchical organizations.[16] Studies are being planned to see if video conferencing *per se* improves the socialization among various categories of healthcare workers. Anecdotal experience suggests that this will be the case.

We have also observed that in-the-room students at T-Health Amphitheater have advantages over distance learners, since the T-Health Amphitheater provides a richer multimedia environment and greater opportunities for student and faculty socialization and exchange. The off-site students, however, have the advantage of greater scheduling flexibility, since they can participate in sessions from alternative learning sites, such as from the workplace or from home. Finally, the T-Health Amphitheater environment has proved to be exceptionally student-friendly. Fea-

tures such as "push-to-talk," when coupled with tracking by video cameras sequentially to the current and next student speaker, create a very positive experience for the students. We are impressed that our students now activity seek out opportunities to participate in T-Health Amphitheater learning sessions.[17]

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