

# Using Distance-Based Technologies for Emergency Medicine Training and Education

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Traditionally, public and primary health care practitioners and planners have considered the provision of emergency medical care to be an inefficient use of health care resources. There is the growing recognition that the long-term sequelae of inappropriately treated acute illness can have longstanding personal, economic, and societal costs, and growing emphasis is being placed on the training of practitioners who have well-constructed therapeutic approaches to acute episodic care. Such practitioners, working within well-planned emergency medical systems, can provide medical care that can complement and enhance the services provided by primary and public health care systems. Poorly trained practitioners working in poorly planned emergency medical systems are likely to provide wasteful and unsuccessful therapies. There is an explosive and global interest in establishing emergency medical systems and training emergency medical practitioners. Health policy planners, health care practitioners, and the general public recognize that the delivery of acute, episodic health care is an essential part of the primary and public health systems.

This global interest in emergency medicine (EM) is manifested in many ways, including the growth of international emergency physician organizations, conferences, and residency training programs [1]. We have the opportunity to use this enthusiasm to establish viable emergency medical systems in many countries. The planning and establishment of effective emergency medical systems requires the development of public and private health care systems, physician education and deployment, training nursing and medical support staff, and the augmentation of public awareness of emergency medical system use. To implement such educational and training programs, health care practitioners and planners are seeking the advice and collaboration of colleagues in other institutions locally and globally. As with any rapidly developing medical field, alliances between practitioners, policy makers, and academicians are important. These alliances allow persons involved to share intellectual and other resources, to foster a sense of collegiality, and to assure that lessons learned in one system are used effectively in another.

In the realm of EM, such collaborations can be grouped into two main categories: (1) on-site visits by an expert or group of experts and (2) the travel of trainees to another site for training. Over the last decade, we have seen several types of expert visits and exchange programs for the dissemination of emergency medical education. Some programs center around informal visits by an individual or group of individuals to a medical community or hospital in another country, whereas others are structured with formal, evaluative teaching programs. Over the past several years, there have been instances for intergovernmental and interagency cooperation to provide for the exchange of medical professionals and knowledge during times of natural and man-made disasters. This cooperation usually involves movement of personnel over large distances, often in difficult situations. More recently, there have been efforts to provide medical direction and education at a distance [2]. These efforts have included the Spacebridge to Armenia project, which allowed medical centers in the United States to provide medical direction in the care of victims of the earthquake in Armenia and allowed medical centers in the United States and Russia to exchange medical education and clinical consultations [3].

Expert site visits for emergency medical education and training often center on grand rounds lectures and the teaching of algorithm-based rapid medical interventions. Workshops focus on EM techniques, such as rapid sequence intubation and disaster management and planning. Excellent examples of such instructional visits are the missions conducted by the members of Emergency International to several countries, including Cuba, China, and Honduras and Nicaragua. Such visits introduce new medical knowledge, strengthen personal and professional relationships, and open the door for further communication and cooperation. These activities foster better emergency medical care and provide impetus for the academic development of EM through academic collaboration in such areas as faculty

development, specialty development, and research. The drawbacks are that implementation of information transferred during isolated visits cannot be continually updated and maintained. To overcome this, there has been a push to include "teach the teacher" aspects to such programs. The benefit is obvious: A single training trip by experienced clinical teachers can train 15 to 20 local instructors. If these new instructors are given adequate time allotment, financial allowances, and basic educational resources, they can train many generations of participants. A drawback to this approach is the limited time availability of local instructors to give repeated courses.

Another method used for the global transfer of EM knowledge is centered on visits of health care professionals and planners to sponsoring institutions. Such programs range from the participation of physicians in full-length residency programs abroad to short-term fellowships or fact-finding visits. Funding sources for such programs are highly variable and include private funding, governments, nongovernmental organizations, and international organizations. Such programs have many advantages, but the major drawbacks are that they can reach only a limited number of participants and are often difficult to coordinate and execute. When travel and lodging expenses are factored in, costs can be high. Costs can be prohibitive when seen in the context of per-capita health expenditures of the participants' countries. Therefore, it is fair to say that although international emergency medical education and exchanges have been expanding, there is a great need for low-cost, continually updated information exchange and training. Global demand for EM training and education is outstripping the supply offered by reputable and seasoned EM practitioners. The supply of dedicated and proficient teachers of EM is constrained by limited monetary resources and time and traveling restrictions. The demand for improved EM services and practitioners is fueled by a public that expects efficient and cost-effective acute episodic health care. This imbalance between supply and demand can be reduced by the appropriate use of telecommunications technologies.

#### Identifying appropriate technologies for emergency medicine training programs

To design programs that can provide education and training at reduced costs, that demand less travel by participants and instructors, and that are sustainable over time and distance, it is important to first ascertain the capabilities and constraints of the group or site that requires the services. Particular attention must be paid to understanding the priorities outlined by existing policies to ensure that new programs are well received. One must know how improved EM services will complement existing health care services and how the training that EM practitioners receive will be used. For example, it is useless to train practitioners in most developing nations with

low per capita health expenditures and no in-hospital capability to receive and treat a resuscitated patient in ACLS methodologies. On the other hand, if the receiving hospital has good operative capabilities, it makes sense to train primary emergency practitioners to recognize trauma and use ATLS algorithms to maximize the "golden hour" and prepare trauma patients for operative intervention. The determination of such capabilities and priorities is best made by potential trainees in consultation with local medical educators, health policy officials, and funding organizations. Strategic alliances between educational institutions must be made to maximize resource sharing and minimize redundancy of training programs. Resources spent at this early stage have a significant cost/benefit ratio, and emphasis should be placed on maximizing this planning stage. For example, if travel dollars are to be expended on a cross-national training project, they should be skewed toward sending expert teachers and planners in the earliest stages of the project to outline program priorities, forge strategic alliances, determine evaluation strategies, and develop guidelines to insure the program sustainability.

Once program acceptance and viability is studied, it is important to design an educational program that is appropriate for the target audience. Most training and education programs in EM internationally are geared toward the retraining of physicians and nurses employed in other capacities. Such training programs have several challenges, such as requiring trainees to carve out time from current work schedules to accommodate training programs and defining compensation (or lack thereof) for allotting time to training programs. Educational programs have to be designed to be appropriate for the adult, self-motivated learner. Trainees expect their education to be focused, strategic, and goal oriented. Instruction has to be streamlined to ensure that the basic transfer of knowledge occurs but that the recipient be able to tailor the instructional program to maximize personal gain and promote self-paced learning. These qualities are an ideal foundation for distance-based curricula.

#### Mediated learning: an overview

One of the ways that EM education and training can be conducted between institutions in different countries or in different parts of the same country is by using distance-based educational methodologies. Technology enables us to create learning environments where teachers, students, and instructional content are in different locations. Although the term "distance education" has been adopted to describe the process, a better term in our view is "mediated learning." Using the term "mediated learning" enables instructional designers to focus on the best combination of traditional instruction and technology-enhanced instruction that will enable the instructor and students to achieve specific instructional outcomes as extensions to

traditional learning experiences or as entirely mediated experiences. As such, identification of the specific instructional goals to be achieved must be clearly articulated. After this step, appropriate instructional technologies can be applied when and where they meet these goals.

#### Synchronous instructional delivery

During a synchronous lesson, instructors and students interact with each other in real time. In the traditional classroom experience, the instructor and the students must be present in the same physical space for learning to occur. Technology allows us to replicate the classroom experience for instructors and students despite the fact that they are not in the same geographic location. Real-time interaction between teachers and students occurs. The format is primarily lecture based but can be expanded to be used for some small-group or discussion-based learning. The degree of replication depends on the technologies chosen to facilitate the teaching. The introduction of technology into synchronous teaching often requires changes in teaching styles.

#### Live video

Due to the nature of synchronous teaching and learning, the technology most often used to enhance or enable this form of instruction involves live video, particularly in distance education. Although video is not the only technologic means of creating a mediated synchronous instructional environment, it represents the closest approximation of the dynamics of instructor-led, lecture-based teaching.

#### Uncompressed (point to point) video

Video has often been viewed as the "next best thing" to face-to-face teaching. With an uncompressed video link (eg, satellite, cable, etc.), the instructor and students interact as if they were in the same location. Although video links are time dependent (ie, instructors and students must be connected at the same time), a video link supports high-quality content delivery and interactions. With advanced switching capabilities, data (eg, slides, charts, and graphs) and the video content or lecture can be transmitted to the receivers. In a two-way video link, the recipients (students) of the signal and the sender (instructor) must be located in facilities that permit the reception and transmission of the video signal. This type of approach requires advanced video transmission technologies. Although these may exist in many locations, engineering support and required technologies limit the support of a wide range of teaching approaches. The most significant benefit to this type of instructional delivery model is that it is generally known and familiar to the participants. The most significant cost is the location restrictions because each site must have the required video

equipment to actively engage in the learning environment. In addition, the interconnection of two or more sites often causes management and engineering costs to become prohibitive. From a strictly instructional standpoint, the collocation of groups or the entire class in one location can provide needed control over classroom interactions and general class management. The moderation of learners and their interactions becomes increasingly difficult because the instructor may not be able to see all of the students at different locations.

#### Compressed video

Although uncompressed video provides the highest quality of video presentation, several compressed or computer-based video transmission technologies have emerged that significantly extend its usefulness in delivering instruction to students. Early models using compressed computer video often relied on costly digital telephone circuits (ISDN) that had limited capacity (and thus limited quality) were subject to difficulties in integrating various vendor technologies and required expensive equipment. The recent advances in personal computer (PC) capacity and the increasing penetration of the Internet into households and organizations has helped to expand the possibilities and reduce the costs of compressed video point to point and point to multipoint. The major issue facing compressed video links (video conferencing) remains one of quality. PCs and the required Internet connections often do not have enough data processing capacity to transmit and receive high-quality images. The gap between compressed dedicated connections (ie, ISDN video conferencing) is closing; however, neither PC, Internet-based video conferencing, nor higher-end ISDN video transmissions have equaled analog video (eg, satellite or direct cable). Two significant advances in the PC and Internet areas provide significant promise of increasing the quality of the connections. MPEG video compression can equal VHS/PAL video quality and can match Beta and other production-level video signals. One of the major stumbling blocks to widespread adoption of this and other high-quality compressed video technologies remains the required network bandwidth and to a lesser extent the required PC processing power. The biggest obstacle to compressed video connections using PCs and the Internet is the reliability of the data connections and, most importantly, the capacity of the data connection. The inclusion of many intermediary service providers and technologies exacerbate data connection capacity problems. As these quality-of-service issues are resolved, the quality and corresponding utility of compressed video will increase. The presence of government and private data networks can significantly improve the utility of ISDN or computer-based video conferencing (MPEG and others).

The biggest advantage of computer-based video delivery that students do not have to travel to a single site; because of this, the opportunities for students to receive and interact with content providers or instructors are

increased. However, even with the ability to deliver high-quality video course information to many students in many locations, the interactions among the students and with the instructor become more complicated, resulting in a less structured environment. Depending on the instructional design chosen, this lack of structure (as compared with a traditional face-to-face class) can be a benefit or an obstacle. Advances in software seek to improve the interaction by providing more classroom management components. This approach must be implemented with an understanding that available technologies may affect the instructional design process and the resulting instructional delivery.

Many efforts to create synchronous teaching and learning solutions fail because they are based on a desire to replicate the face-to-face teaching and learning approaches used in most educational settings. The major limitations of the synchronous approaches discussed here may result in a redefinition of the instructional goals and value placed on specific types of interactions. A desire to replicate traditional teaching and learning with video can create problems because the technologies are still being developed.

#### Synchronous audio, visuals, and chat

Some students may not have access to technologies necessary to support features such as video [4,5]. An innovative approach used at George Washington University has involved the use of audio lectures with synchronized slides (delivered synchronously and asynchronously). This approach has reduced the instructional content to the audio (lecture) and slides (key points, images) that are critical to knowledge transfer. The technologies required to support this type of delivery are relatively common in PCs and personal connections to the Internet (low-speed network connections or standalone, computer-based use). The realization of this approach was possible as lecturers discovered that their presence in the classroom, particularly in large lecture halls, was less important than once thought. Additionally, anecdotal evidence suggests that students have more ability to interact because their questions can be queued by the faculty and asked anonymously, which increases student willingness to interact with the faculty. Interaction with students and instructional points addressing questions can be immediately incorporated into the synchronous delivery, whereas in the asynchronous mode the questions are addressed after students have seen the lecture. The synchronous audio approach has been successfully implemented in courses for the purposes of office hours and other forms of student support. Students are able to ask questions of a faculty member at a prescribed time, and the faculty member can respond with audio and visuals (eg, images, slides, whiteboard) in answering the question. This approach can be used in asynchronous teaching as well, with the limitation being the immediacy of feedback and interactions between faculty and students.

### Asynchronous instructional delivery

In an asynchronous learning environment, geographically dispersed students and faculty can interact with each other and with the course material at different times. As World Wide Web access and functionality increase, several key benefits of asynchronous teaching can be realized. Students can access materials 24 hours a day, thereby providing them with increased flexibility [6-9]. Students and faculty may access materials from anywhere in the world at any time, and the requirement of students or instructors being in the same physical location is eliminated [6,7]. This fact forces instructional designers to develop student-focused learning exercises because students and instructors work independently [10]. Because the instructors are not always available as the students are working, the transition to asynchronous teaching requires additional time in the preparation of instructional materials. It also requires more time related to capitalizing on the interactions that do exist [11-13]. In some cases, faculty indicate that they have more individual interaction with their students through asynchronous means [6]. Studies have shown that learning occurring between students can increase [9,14] and that learning can become more learner centered [10]. Students have time to think and reflect on the instructional material [8].

Technology provides the catalyst and tools necessary to make these instructional delivery changes. The ability to interact through posted messages, e-mail, and shared documents places a new and significant burden on the students that includes increasing the need for them to be self-motivated [15] and to have a strong willingness to participate [9]. However, the economic and geographic benefits coupled with careful instructional design can make this a viable alternative to traditional teaching styles [7,11-13]. A critical component of the instructional design process is a realization that students must have access to the technology. Even with increasing public access to telecommunications technologies, there remains the significant challenge of ensuring that students have access to and an understanding of the technologies involved [4,5]. The most significant impact, particularly for the experienced instructor, is the reduction in nonverbal interactions lost by having the instruction and learning separated or mediated by technology [5].

### Hybrid instructional design

A combination of asynchronous and synchronous teaching can provide the students and instructors the full benefits of technology-enhanced learning. In some content areas, the synchronous teaching and learning of a traditional classroom may be augmented with technology, particularly when the technology facilitates virtual experiences, such as dangerous lab experiments, or demonstrations requiring expensive equipment. For example, in an undergraduate chemistry course at George Washington University,

the instructor uses video-based experiments that can be demonstrated in lecture halls to large numbers of students without requiring a full laboratory setting. This approach enables pauses and replays of the chemical reactions and increases the ability for students to see the demonstration. In another project, faculty are using video and virtual experiences to expose medical students to pediatric cases that may not be at hand at the time of a particular session or in a particular hospital. These areas of "hands-on" training can be recreated in a virtual form; however, often they need some form of physical experience based exposure as well. Even in these areas, the needs must be carefully analyzed to identify the core learning outcomes desired to ensure that one is not simply doing it a particular way because that is how it was always done.

A hybrid approach to instructional design and implementation is often desired and required to make the use of technology successful and cost effective. **Box 1** provides an example of a hybrid asynchronous/synchronous course design.

#### Telecommunication technologies for emergency medicine

There are many ways to design meaningful and cost-effective mediated learning experiences for EM education and training programs. There is a large array of technologic innovations, equipment designs, and teaching methods that can be integrated and tailored to meet provider and trainee requirements. Equipment that can be used ranges from the most basic and least expensive (eg, audiocassette recorders and mimeographed manuals) to the most expensive (eg, video conferencing centers). Information transfer can be accomplished by using any combination of written materials, audio-based lessons, or video-based lessons [16]. Telecommunications methods

##### Box 1. Synchronous/asynchronous hybrid

- Course content delivered by compressed video conferencing (live)
- Delivered to specific limited physical locations (may be multiple)
- Facilitators at each location (in addition to faculty at remote site) Assist with assignment collection and review  
Lead discussions, answer questions
- Assignments submitted electronically  
Laboratory experiences virtual or local to the students as needed
- Students and faculty interact asynchronously through posted messages and e-mail
- Potential for live interactions by video conferencing

that can be used to transfer the information include postal mailings, radio broadcasts, Internet document transfers, or telephone lines. Teacher-student interactions can be synchronous or asynchronous to accommodate for time zone and other scheduling issues. Mediated learning that uses new technologies will continue to expand, and we can expect start-up and operational costs to diminish. With this in mind, we feel that individuals and institutions interested in EM education and training should investigate new technologies to fill the ever-expanding global demand for such services.

Internationally, some of the potential effects of using these technologies to improve medical educational and training are hindered by the "digital divide." The average OECD country has 40 times the per capita computers, 110 times the per capita mobile phones, and 1600 times as many Internet hosts as a sub-Saharan African country (excluding South Africa). Language is also an important barrier, with three fourths of web sites being in English, a language understood by only 1 in 10 people globally. Spanish and Portuguese account for only 4% of the available web sites despite being spoken by more people than those who speak English. Expenditure in infrastructure is equally skewed. For example, the expenditure per capita for telecommunications of an OECD country to a South Asian country approaches 10:1 [17].

Many commercial, intergovernmental, and governmental projects are addressing the cross-country and within-country digital divide as a priority area. Between 1995 and 1998, developing countries connected 155 million telephone lines, 105 million mobile subscribers, and 4 million leased lines, representing average annual growths of 14%, 8%, and 27%, respectively [17]. Those least entrenched in existing systems stand to benefit the most from "leapfrogging technologies," such as digital satellite radio. In addition, developing countries have the opportunity to learn from infrastructure and technology lessons learned in more developed countries.

One such recent venture that we are involved with is the World Health Channel, which is a digital radio channel that can address the needs of health information and education in developing countries. This modality is capable of datacasting up to 256 kb/s in rural areas where there is no electricity or telecommunications infrastructure. Inexpensive receiver units can run on solar power or kerosene, making access to information possible in remote areas. Successful pilot programs have occurred in Kenya, Tanzania, and Nigeria. For example, using digital satellite downloads have been used to redistribute data files (eg, detailed patient case descriptions and didactic PowerPoint presentations) in an asynchronous manner. Real-time audio delivery is used to provide the live (synchronous) presentation of the lecture. Post-lecture discussions are conducted through telephone or World Wide Web links. Using this hybrid approach, several interactive Grand Rounds presentations have occurred on such seminal topics as prenatal HIV prevention and severe pediatric malaria with the synchronous participation of practitioners in Great Britain, the United

States, and several sub-Saharan nations. In March 2002, at a SAEM didactic session on mediated learning, a panelist based in London sent his PowerPoint lecture via the web and delivered the audio portion via a telephone link. He was able to answer questions and participate as a panelist. Neither the audience nor his fellow panelists felt that this method of delivery had deterred from the effectiveness of his lecture.

In 2001, the Ronald Reagan Institute of Emergency Medicine collaborated with the London-based Interactive Health Network and the World Bank to conduct a NATO-sponsored conference on Telemedicine in Central Asia. The conference site was in Tashkent, Uzbekistan, and participants were from several Central Asian countries. Satellite and Internet-based telecommunications technologies were used for planning and implementing the conference, thereby saving traveling expenses in the early stages. Real-time teleconferencing and downloaded PowerPoint presentations supplemented with audio lectures allowed for the conference speakers and panelists to be located at three different centers. Funds that had been earmarked for the travel and lodging of conference presenters were used to bring conference participants from neighboring countries, thereby providing a regional instead of a national conference. In addition, high-ranking government officials participated in some of the discussions and lectures, allowing them exposure to the potential use of telecommunications technologies for providing cost-effective educational experiences in a vast region with diverse medical and technologic challenges.

#### Creating successful mediated learning programs

Before choosing a technologic solution that meets learning outcomes, one must understand the learning outcomes and the constituencies involved in the creation and consumption of the instructional content. One must (1) outline the instructional content and target instructional outcomes [18]; (2) identify the student group and define their learning goals and expectations [19]; (3) understand the students' learning styles and identify their access to and ease with technologies that would be used for mediated learning; (4) identify faculty and gauge their skill level for using these technologies [20,21]; and (5) ascertain if faculty have the time and resources needed for conducting technology mediated courses that might require additional time for course preparation, delivery, and student interaction [13,20,22-24].

If technology-mediated courses are to be initiated, there must be institutional and technical support for faculty and students. This involves technical support during course development, production support, and one-on-one in time support [20,23-26]. Because faculty members benefit greatly from the experience of others who have developed expertise in using instructional technologies, it is important that provisions be made for such peer support [26].

## Summary

Cost-effective and sustainable ways of continuing to improve emergency medical services and education worldwide must be pursued if the field is to continue to expand globally. Distance-based learning and the use of telecommunications advances present us with an ideal opportunity to improve international medical education. Such technologies can overcome the financial and logistic constraints of travel and can complement existing exchanges.

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