EMERGENCY! Medicine and Modern Education Technology.

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Increasingly rapid progress of medical science and the continuous development of new methods of clinical treatment demand that every practitioner at any level of medical practice continues to update the essential knowledge acquired during professional education. Only a few years after medical school, new facts will have emerged, new treatments devised and approved, and new tools will have become available. In order to stay "current," continuous exposure to training ceased to belong to the realm of commendable intellectual curiosity, instead becoming a frequently quite costly and time-consuming "must." For those living and working in close proximity to medical training centers such as universities or teaching hospitals, maintenance of adequate knowledge and skills level is significantly less burdensome than for those operating in rural or remote regions. Hence, it is the lesser group of medical practitioners for whom the advent of modern medical education technology is one of the most important developments in medicine.[1,2,3,4,5,6]

As with the majority of the new changes in business, in medicine the principal carrier platform for such changes is provided by the ever-widening acceptance and use of the Internet and Internet/Web-based technologies.[7] The CD-ROM, while still preeminently practical[8,9,10,11] and even proclaimed a "step before virtual reality,[8,12] has a number of disadvantages. First of all, despite significant interactivity with the contents of the disk, the material contained is, essentially, static. Once placed on the disk, it cannot be changed or easily upgraded unless the user is willing to pay for the upgrade. Hence, particularly in the realm of rapidly advancing branches of medicine such as genetics or pharmacology, the contents of the disk become rapidly obsolete and may even become misleading, particularly in situations where new evidence indicates that old practices may be either ineffective or even harmful. Another barrier to the wide-spread use of CD-ROMs is their inherent cost. Medical textbooks are famous for their prices which, in turn, are driven by the limited size of publication, very high quality of the illustrations, and (typically), equally high quality of overall production. CD-ROMS, by virtue of containing a significantly larger amount of information including video clips, complex 3-D diagrams, interactive testing tools, etc.,[13,14] may be quite frequently and despite a fairly low cost of production, even more expensive than the traditional textbooks. While either of these issues does not pose an insurmountable difficulty for a large medical library at a university-affiliated medical school, it may be a significant problem for an individual rural physician, nurse, or a paramedic. The final obstacle — that of the familiarity with underlying technology and the ability to implement technology-based tools efficiently[15] — is common to essentially all fields in which computer-based methods are introduced and implemented with ever-increasing vigor. All these issues notwithstanding, CD-ROM-based medical education and training do have a future, especially when combined into larger "teaching blocks" incorporating Web-based components[16] provided by dedicated organizations that will maintain and expand both the quality and currency of information contained on the discs.

Handheld devices or PDAs (Personal Digital Assistants) hold a very significant promise in medical practice.[16,17,18,19,20] The new generation of PDAs, equipped with wireless communication capability, offers medical personnel convenient and rapid access to medical information essential for appropriate medical decision making[18,21] and field[22] and ambulatory[23] operations as tools ensuring appropriate administration of drugs.[20] In the educational setting, PDAs find rapidly increasing application in training at a variety of levels;[17,24] and their use in critical care has been successfully tested as well.[25] While highly practical, PDAs suffer from a number of disadvantages that need to be recognized and accepted as the unavoidable consequence of their size, readability under adverse conditions, stability and range of the wireless network that forms the communications platform, and, finally, the ergonomic factors. The latter may have a particularly strong influence on the usefulness of PDAs in adverse environments frequently encountered during emergency field operations. It also must be clearly recognized that PDAs are essentially nothing but eminently portable textbooks that save time in searching and finding relevant, concise information when the need for such information is acute. There is, however, hardly any doubt that the time of handheld computing devices in medicine is yet to come, and that the present operational limitations are nothing else but the consequence of a very limited "maturity of the field" not only in medicine but in general as well. The recent introduction of a combined cellular phone and a handheld computer as a single, seamlessly integrated unit indicates both the youth of the field and its immense potential that will expand as an exponent of both the evolving technology and ever more complex and useful content. The major area of PDA deficiency, at least as far their current form and capabilities are concerned, is providing worthwhile support and "hand guidance" for medical personnel in need of immediate, "live" help that may be critical in order to save a patient's life. For this, one must look into the field collectively known as "telemedicine" and, to a large degree, its still-unfulfilled promise.

Similar to virtual reality (VR), telemedicine became a concept so broad that it literally lost its meaning. In VR we have virtual offices that are nothing more than word processing, spreadsheets, graphics, or other forms of software available to employees working away from their offices. There is nothing *virtual* about it other than substitution of one environment (office) for another (home or remote location). The concept of a broadly accessible, truly virtual, yet readily interactive environment created through advances in computer technology is, with some notable exceptions, nonexistent. In part, this is the direct consequence of continued high prices, inadequate bandwidth to allow remote projection of such environments, and the complexities of interaction between virtual sites.[26]

In telemedicine, everything even remotely connected to the practice of the trade becomes both medical and "tele-" as long as the activity is executed over a distance — even if the distance is no further than two floors separating the two sites. Patient data transfer, administrative issues associated with a clinic or a hospital, patient monitoring, or consultation, all become the part of the great, amorphous arena collectively termed "telemedicine," where distinction between true practice of medicine and the execution of all its supporting activities become increasingly blurred.[27] Unsurprisingly, therefore, there are a considerable number of definitions, all striving to convey the purist definition; and all, invariably, either too broad or too constraining.

Despite great advances in telecommunications, live video technologies that now allow transmission of 3-D imagery, and a number of increasingly sophisticated tools available to the "telephysician," telemedicine remains very much at the same level of operational sophistication as in the days of its nascence, perhaps even regressed a little. This is, unquestionably, a controversial view. Yet, when the concept was originally developed in 1968 by Dr. K. Bird, its main purpose was to provide real-time medical assistance from a Boston hospital to patients at the Boston airport.[27] Real-time medical assistance was the key element. Today, telemedicine continues to remain largely consultative and static.

While remote consultation is a wonderful thing, there is nothing new about it. Telephone, fax, and radio have been used for decades to serve precisely such a purpose. It is a forgotten fact, but ship-to-shore radio was probably the earliest form of telemedical practice, with medical assistance provided as early as 1906.[28] The progress in teleradiology or teledermatology is more than impressive, and correct diagnoses by highly specialized physicians can be performed on patients located thousands of miles away. However, both disciplines lack the dynamic element and rely on the analysis and interaction with the images *of* the patient rather than interaction *with* the live patient. While the argument of telepsychology can be used to counteract the postulate that modern telemedicine continues its development as a static discipline, telepsychology represents, after all, nothing but video-conferencing used for a highly specialized purpose.

In a show of frustration with the conceptual state of the field, surgeons created the concept of "telesurgery," and emergency and trauma physicians created emergency and trauma telemedicine. These two disciplines embody both the element of real-time presence within the medical environment and an active interaction with it, either by means of remotely controlled devices (e.g., remote robotic surgeon) or by affecting the required actions through voice commands using, for instance, wearable emergency telemedical communication and viewing systems that connect the distant managing physician with the personnel in direct contact with the patient. In either case, a new element has been introduced — that of medical telepresence, whereby the principal remote participant (a physician) conducts medical activities (treatment) as if present on the patient site. Recently performed telerobotic surgery is probably the most sophisticated example of medical telepresence.[29]

The highly powerful concept of medical telepresence can also be applied to medical training, particularly in the arena of training based on simulation.[30] Considering the fact that computerized patient simulators are probably among the most expensive and globally scarce training tools in existence, the development of an Internet-based environment that provides real-time access to and interactivity of the trainee with the simulator is a major step forward in utilization of this new technology. It is very likely that in the near future remote, simulation-based training will provide the most effective and widespread tool for the continuous maintenance of medical knowledge and skills (i.e. medical readiness). The currently unrealized potential of the concept is operational familiarization of the new generation of physicians, nurses, and paramedics with the medium of telemedicine and the involved technology.

Remote, simulation-based training encompasses all elements of the original notions of what telemedicine ought to be as applied to the Boston airport.[31] The remote trainees must address pressing, even potentially lethal medical issues in real time by providing rapid diagnosis, stabilization, and initial treatment, followed by definitive diagnosis and patient disposition. The simulator behaves like a real patient, and its life expectancy may be severely limited as in, for example, cases of heart attack or major trauma. The sense of urgency and the "adrenaline rush" of a medical specialist on the scene of an accident become real; the frustrations are palpable; and the need for correct, speedy action is as badly needed as it is in real life. The sense of physical presence at the site of medical emergency is therefore overwhelming and conveys the essence of medical telepresence. The transformation of a static, consultative environment into a dynamically interactive one is not only striking but, more importantly, emphasizes the missing element of the majority of telemedicine operations today — the ability to provide immediate yet remote emergent medical assistance anywhere, any time, and without any other constraint but the resource limitations at the patient site. Thus, interactive, distance-based simulation appears to stand at the top of the pyramid of the currently available technologies aimed at the education and training of doctors, nurses, and paramedics. Its use allows putting all elements of medical education, both theoretical and practical, into a training exercise where the stakes, albeit artificial, are essentially the same as those encountered in real life — the "death" of a simulator ought to be taken just as seriously as the death of the patient. Both may be the ultimate indicators of inadequate training, readiness, or even confidence — yet the first only permits repetition until the student masters the proper approach to perfection. The use of simulation dispels ethical constraints — any mistake, even the most unlikely one, can be made in a harmless environment. The student then learn from their decisions and results that ensue. There is no doubt that the world of medical training will progress in the direction of medical telepresence, most likely based on the ASP (Application Software Provider) concept. The costs of acquiring extremely expensive technologies by individuals or small training sites is prohibitive, and the rapid evolution of all relevant technologies makes the latest and most effective forms available only to the richest few. Moreover, a hopefully rapid transformation from facility-based activities to ASP-based operations will make advanced forms of training realistically available to the "underdogs" of the medical world — medical practitioners working in rural and remote regions and those who work in the less developed countries (LDCs) whose economies will not allow acquisition of simulation or virtual reality training facilities.

There is a growing need for urgent and semi-urgent medical care throughout the world; there is the continuous threat of mass casualties resulting from natural and man-made cataclysms; and there is an ever-increasing trend toward continuous broadening of the range of operational skills, particularly among the remote medical workers. All these needs can be easily reduced (if not eliminated) by the transformation of today's medical training practices based on the principles of individual training centers into a dynamic combination of telepresence, telerobotics, and simulation rooted in the ASP concept. The most immediate consequence of such a progression will be a highly uniform level of medical care throughout the world. However, and even more significantly, appropriate use of IT technologies will ultimately provide all patients with equal access to the best medical expertise that today still remains restricted to the best medical training centers and academic hospitals.[32]

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