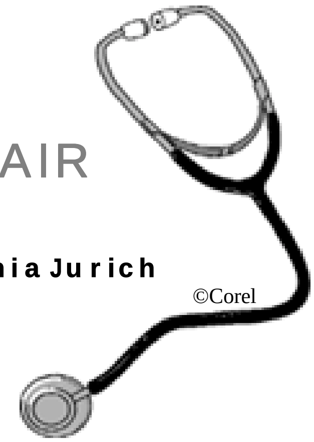
TECHNOLOGY FOR SKILL TRAINING:

A MEDICAL AFFAIR



By Sonia Jurich

The process of forming medical doctors is of extreme concern for all members of society who, at some moment, will have life or limb at the hands of these doctors. It is not surprising then, that medical education is so similar to a process of apprenticeship: long, intensive and demanding. It is not surprising also that medical schools do not tend to follow educational fads. Respected medical schools have traditionally used instructional strategies that integrate academics and skill formation, utilize hands-on and reality-based approaches, and rely on technology to support and enhance human knowledge.

From the beginning, physicians and medical researchers recognized the potential of Information and Communication Technologies (ICT) for medical education and research. Common educational usages of ICTs are *tutorials* that enhance the information obtained in traditional classes, *virtual laboratories* that minimize the need for expensive (and cruel) use of lab animals, and *computerized mannequins* that replace human subjects in the training of invasive and risky procedures. As an added value, these instructional resources familiarize the doctor-to-be with technologies that have significant roles in modern medical practice.

The Top of the Line: Complex Simulators

Complex simulators are electromechanical models or mannequins connected to computers that can reproduce specific aspects of human anatomy, physiology and behavior. High-fidelity patient simulators, such as those used by the **Department of Anesthesia and Pain Management at the University of Sidney, Australia** are examples of complex simulators. (http://www.painmgmt.usyd.edu.au/simulat.html) These are computer-controlled mannequins with an electromechanical cart that acts as an interface between the software program and the mannequin. The mannequin is programmed to reproduce many human functions such as speaking, moving and breathing. It also exhibits palpable pulses and measurable blood pressure, and can mimic a number of manifestations associated with diseases, drug interaction and others.

The high-fidelity patient simulators enable students to learn invasive and risky procedures in a discomfort-free, risk-free environment. The mannequin responds as a human patient and can “improve” or “die,” thus indicating the success or failure of the procedure. The student can use the simulator as many times as necessary to become skilled in the technique without the risk of hurting or maiming an actual patient. The Sidney Medical center uses the simulator to train anesthesiologists, specialists whose work involves life-threatening procedures. As a disadvantage, high-fidelity patient simulators require highly complex computer programming and engineering that make their production expensive and their acquisition limited to major medical centers.

Virtual Laboratories:

Among the subjects taught during the basic years of medical school, physiology is particularly challenging. The students need to learn detailed information about minute components that are in dynamic relationships with a myriad of other elements. Moreover, they must be able to integrate this scattered knowledge and, later on, use it to solve problems that may involve life and death decisions. To support the learning process, instructors need to break the complex into small, simple units (e.g., cell membrane physiology). At the same time, they must connect the small within the complex, so that the student can make the necessary associations (from cellular responses to neuromuscular responses to spinal cord injuries, for instance).

Teaching Physiology and the World Wide Web: Electrochemistry and Electrophysiology on the Internet, by

Terry M. Dwyer, John Fleming, James E. Randall, and Thomas G. Coleman (*Advances in Physiology Education*, 18 (1): 2-13, 1997), describes an Internet-based virtual laboratory that teaches the electrochemical reactions that occur at the level of the cell membrane in response to an action potential. The lab can be found at http://phys-main.umsmed.edu (press the "teaching" button on the menu to go to the labs). To write the simulation the authors employed HTML, a language that can be used with a variety of platforms, and JavaScript, an interpreter that enables the construction of interactive exercises over graphical browsers.

The lab interface is divided into four areas. The upper right area includes the problem, lists of equations, and questions. The middle right presents alternative answers for the questions posed. The left area contains the visual information (a diagram of a cell in a large volume of extracellular solution). The banner across the bottom of the screen shows commentaries to the answers given by the students.

The laboratory includes six lessons and two special tools that help the students solve the problems (a Nernst potential calculator and a calculator for the sodium pump). The use of JavaScript allows for a highly interactive interface that students and instructors can easily manipulate. To make changes in the lab, the instructor needs a very simple text editor and a browser to test the output. To work with the lab and try their own experiments, the students need no more than Netscape Navigator 3.0 or a similar browser.

Data on network use makes it possible to trace the students' performance during the lab. The lab was found effective in improving students' understanding of the dynamics involved in the process of action potential at the cellular membrane site, a topic traditionally challenging for beginning medical students. (For those interested, the University of Iowa's Virtual Hospital offers the module as credit for continuing medical education at:
http://www.vh.org/Providers/Simulations/Spirometry/SpirometryHome.html .

The interactive aspect of the lab enables the student to change variables and invites them to experiment and look for answers of questions that may not be asked otherwise.

A virtual lab has many advantages. First, it can be accessed from any place that has a computer connected to the Internet. For instance, when the lab was initially presented, 85-95% of the hits were from university computers. Gradually, the hits from remote sites increased and included both commercial servers and other educational institutions in the U.S. and abroad. Second, a virtual lab is time-independent, and students can return to the lab as many times as needed to solve their doubts. They can also use the lab to explore related problems given in other classes. Third, the lab provides both visual and intellectual stimuli, thus responding to the needs of different types of learners. The interactive aspect of the lab enables the student to change variables and invites them to experiment and look for answers of questions that may not be asked otherwise. Finally, with the development of JAVA and similar languages, interactive labs are becoming relatively easy and inexpensive to produce and can be used to explain phenomena that are hard to demonstrate in real-life labs, such as the electrophysiology of a cell membrane.

Internet-Based Tutorials:

When compared to virtual labs, tutorials require even less computer expertise to produce and, depending on the topic, may be the tool of choice. **Telemedical Education: Teaching Spirometry on the Internet, by E.H. Lum and T.J. Gross (1999, *Advances in Physiology Education*, 21, 1: 55-61),** describes a tutorial used to train general practitioners to conduct and interpret basic pulmonary function tests (PFT). PFT are valuable tools to assess suspected lung diseases, particularly diseases leading to pulmonary damage, such as emphysema. The measurement of expired airflow (Spirometry), is a simple pulmonary function test that can be performed routinely in outpatient situations with the use of a portable device. However, many practitioners do not have the necessary training to utilize this tool adequately. Research shows a pattern of inappropriate requests and misread results in the use of PFT outside the context of specialized laboratories.

The tutorial described in the article is a multimedia package designed to train general practitioners in the use and interpretation of Spirometry. The package is part of the University of Iowa's Virtual Hospital and can be accessed through the University's outreach centers or through the Internet at http://indy.radiology.uiowa.edu. The text, written in HTML, reviews the accepted guidelines for the use and interpretation of Spirometry and provides examples of representative tracings from tests performed at the University's pulmonary laboratory. The package also contains a digitized video of a physician performing the test with detailed information on the changes that occur in airflow and volume throughout the test. At the end of the lesson, a series of fictitious cases are presented, accompanied by actual Spirometry tracings. The trainee is offered a list of possible interpretations for each case and requested to provide the best interpretation possible.

Using a pre- and post-test approach, the authors tested the module with medical students, interns and senior hospital staff. Statistical analysis showed that the module improved test interpretation for all participants, independent of their level of training. Although the highest gains were made by medical students (the group with lowest pre-test scores), even the more experienced staff showed statistically significant improvement in the post-test. Score gains were found across the entire range of pulmonary disorders tested. Participants had no difficulty accessing and using the module. Despite the lack of advertisement, the module received about 4,000 hits during the period it was tested and an extra 122 individuals responded to the test. Those were mostly medical students, but also physicians, respiratory therapists and nurses from different parts of the U.S. and countries as far as Italy, Brazil and Malaysia.

Conclusions

Research seems to indicate that computer-based instruction has positive influence in the learning process, despite traditional wisdom questioning such influence. **Student Perceptions and Learning Outcomes of Computer-Assisted Versus Traditional Instruction in Physiology, by Daniel Richardson (*Advances in Physiology Education*, 18 (1): 55-58, 1997)** is an interesting article describing the discrepancy between student perception and actual learning outcomes. In this research, the authors compare the teaching of a specific topic of physiology using three different techniques: standard lectures, computer-assisted lectures, and computer laboratory assignments. Students perceived standard lectures as the most effective method. However, the tests showed that students who were taught with computer laboratories scored higher than the other two groups, and those taught by standard lectures had the lowest scores.

Dewyer et al. observe that, to realize the full potential of computer-based instructional material, the authors must ensure that the material is of high quality in both visual presentation and content. They also must keep the material updated. In addition, they must strive to reconcile their ambitious designs with the users' most probable equipment. Instructional materials that are platform-dependent, or use applications that are not easily accessible will have limited impact because many students will be unable to use them.

Recent progress in computer-related technologies offers new and exciting opportunities for medical training. Increased memory and faster processors enable the use of more complex and larger programs. New languages, such as JAVA, open new horizons in the design of interactive programs. In addition, specialties, such as Bioengineering, place Medicine at the cutting edge in the use of technologies for education, research and development. This article described a range of ICT uses for professional training, from the highly sophisticated (and expensive) patient simulators to simple tutorials that were written by medical instructors with no computer specialization. Some of these ideas can be easily adapted to other areas of skill formation. The secondary effect of using technology in education and training is to prepare a workforce that is competent in both the topic of the training and the technology itself. The investment is thus worthwhile.

THE SECONDARY EFFECT OF USING TECHNOLOGY IN EDUCATION AND TRAINING IS TO PREPARE A WORKFORCE THAT IS COMPETENT IN BOTH THE TOPIC OF THE TRAINING AND THE TECHNOLOGY ITSELF.