Simulation and new learning technologies

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SUMMARY Changes in medical practice that limit patient availability and instructors' time have resulted in poor physical diagnosis skills by learners at all levels. Advanced simulation technology, including the use of sophisticated multimedia computer systems, helps to address this problem. For many years 'Harvey', the Cardiology Patient Simulator, and the UMedic Multimédia Computer system have proven to be effective tools to teach and assess bedside cardiovascular skills when they are integrated into the required curriculum of medical school and postgraduate training. In the future, virtual reality technology, based initially on data from the Visible Human Data set, will provide the majority of simulation-based training. Models that provide a high level of visual fidelity and use sophisticated haptic devices that simulate the 'touch and feel' of a procedure or examination are now being used in selected medical centers. The presence of these tools is not enough. Evidence-based outcomes must show these systems to be effective instruments for teaching and assessment, and medical educators must be willing to effect change in medical education to ensure the appropriate use of these systems in the next millennium.

Introduction

In the past century, there has been an exponential growth in our knowledge of the human body, its structures, its functions, what can go wrong with it and why. The major advances in diagnostic tests and imaging have been truly remarkable and, along with our ability to prevent or cure illness and prolong active life, have had a major impact on the quality of human condition. Over the past few decades, medical educators have been quick to embrace new technologies and pedagogical approaches such as informatics, problem-based learning and just-in-time learning in an effort to help students deal with the problem of the growing information overload.

Medical knowledge, however, has advanced more rapidly than medical education. Even as we unravel the genome and begin the era of proteomics, we use outdated and often ineffective methods to teach skills and mold attitudes. Fortunately, positive changes are on the horizon for medical education to ensure the appropriate use of these systems in the next millennium.

Chinese proverb: "To prophesy is not easy. Particularly in regard to the future."

Current problems in medical skills training: a common scenario

Peter Smith, a senior medical student, exited the OSCE station with his preceptor and felt he had made the correct diagnosis and initial treatment plan regarding his 72 year-old patient with exertional angina pectoris: unstable angina secondary to coronary artery disease to be confirmed by an exercise stress test. To his surprise and disappointment, he was notified that his patient's exertional angina was the result of critical aortic stenosis, a diagnosis he missed by not appreciating the long systolic murmur at the patient's upper right sternal edge. Worse, the patient would be at risk for sudden cardiac death if he were to undergo exercise stress testing. Despite his disappointment, Peter was relieved to learn that he would still pass and graduate from medical school.

Over the next few days, Peter reflected on the OSCE encounter and wondered how he, a graduating medical student, had missed an important bedside finding. He was upset with himself for not eliciting the finding, but then reflected on the adequacy of his medical-school training in auscultatory skills.

Skills training during preclinical years

After each of his first two years of medical school, Mr Smith underwent an assessment of his ability to perform a complete physical examination. However, during each of these sessions, he really went 'through the motions' of the exam and was not tested on his ability to elicit a specific finding. He learned about the physical findings of aortic valve stenosis from a textbook rather than from personal experience. During his first 2 years of medical school, his mentors seemed unconcerned about his inability to perform a detailed, organ-specific physical examination since he and his classmates were never graded on their clinical skills (Kassebaum & Eaglen, 1999).

Skips training during clinical years

During his third-year clinical clerkships, Mr Smith spent more time in conference rooms, discussing patient care or

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related journal articles with the ward team, than he did at patients’ bedsides honing his skills (Shankel & Mazzaferrri, 1986). When the ward team did visit a patient with an important physical finding, there was limited time to practice his exam skills (Collins et al., 1978). This resulted from:

- occasional reluctance or embarrassment of patients to expose themselves to the large number of individuals on the ward team;
- impatience of team residents eager to conclude rounds quickly in order to attend afternoon clinic;
- impatience of attendings eager to conclude rounds quickly in order to attend a private patient clinic or meeting, perform a procedure or experiment, etc.;
- difficulty locating patients undergoing diagnostic tests;
- rapid patient discharges due to efficient managed-care caseworkers.

Peter was aware of the availability of CD-ROMs and tapes of heart murmurs in the library. However, these were optional resources with content that was never required or tested. He knew of students at other schools that had these types of resources as part of their core curriculum and wondered whether they were better skilled than he. Peter realized that in a few months he would be seeing patients on his own who may also have important auscultatory findings.

He further worried, if his auscultatory skills suffered, what about his ability to perform a competent neurologic or ophthalmologic examination? Why did those in charge of his medical education not make sure he possessed the skills necessary to be a physician before allowing him to graduate? Unfortunately for Peter, deficiencies in die performance of clinical skills are not limited to medical students; they are also prescrit among residents in internal medicine (Mangione & Nieman, 1997; St Clair et al., 1992), emergency medicine (Jones et al., 1997), and pediatrics (Gaskin et al., 2000).

Simulation technology in the core curriculum: a potentiol solution

The above fictitious case highlights many of the problems occurring in academic medical centers today as a result of reduced physician teaching time and reduced availability of patients as educational resources. The increased use of simulation technology to supplement skills training with repetitious, standardized training would appear to be a logical solution to the problem. Despite the widespread availability of simulation technology, however, its use has not yet become part of the core curriculum at most medical schools. This may soon change, regardless of the opinions of individual faculty and medical educators. Several key organizations have recognized the role of simulation technology in medical education and have recently implemented guidelines or programs to foster its development. The members of the American Board of Internal Medicine shares this view as reflected in its decision to form the Physical Examination Self-Evaluation Process Committee. This committee has developed a multimedia computer-based, self-assessment program focusing on “physical examination and physical diagnosis skills” (Norcini, 1993).

Physical body simulators

Simulators now available and routinely used in medical education vary in their complexity and ability to represent real-patient situations. Some models permit examination and manipulation by the student, but do not respond or provide feedback. Others are more sophisticated and interact with die student. The simplest simulators resemble a person in size and weight only, much like a mannequin in a department store. These types of simulators are used extensively in trauma cases to replicate automobile accident victims. Learners use these simulators to practice cervical-collar placement, removal of patients from automobiles, and other ways to stabilize accident victims. These simulators typically have permanent and non-modifiable ‘injuries’ such as head lacerations and contusions, a dilated pupil, or compound leg fractures. Any sense of realism is due to the scenario rather than the simulator itself. The simulator does not respond to any action and its sole requirement is to represent a ‘body’, i.e. to be the approximate size and weight of a typical person.

Anatomic-pathologic simulators

Another type of simulator is the simple anatomical model used to train students how to perform a single component of the physical examination. Examples include models for breast examination, eye examination, car examination, female pelvic examination and male rectal examination. The advantage of such simulators is that they enable teaching on a practical level without any imposition on real patients, especially with sensitive topics such as pelvic examination. When using simulators of lower fidelity it is important to appreciate their limitations and use them in situations that maximize their strengths (Macintosh and Chard, 1997).

Procedural skills simulators

Other simulators are used to learn, practice and assess procedural and practical skills. These simulators are currently used to train learners in the following techniques:

- intravenous access via cannula insertion and surgical cut down;
- catheterization of the male and female bladder;
- airway management, including intubation (some of these devices, including the Cricothyrotomy Simulator [Armstrong Medical Industries, Inc., Uncolnshire, IL] allow the learner to practice catheter oxygenation/jet ventilation via the cricothyroid membrane in cases of laryngeal, pharyngeal, lingual tonsilar and epiglottic pathology; this is important because die clinical opportunities for employing this kind of technique are otherwise rare);
- soft tissue injection and aspiration of kne, shoulder, elbow and wrist joints;
- ureteroscopy for practice of kidney stone removal.

Surgical simulators

Surgical training is one area that seems ideally suited for the use of simulators. Proficiency in surgery requires knowledge
of underlying anatomy, dexterity and frequent practice. Despite this apparent fit, there have not been many valid studies examining the use of simulators for surgical training. Simulators are currently available to train learners in the following surgical techniques:

- simple wound closure, evaluating suture tension and accuracy of placement;
- bowel anastomosis (closure), using sutures and staples;
- laparotomy;
- episiotomy and theed-degree tear of the perineum (with ability to practice suture repair at multiple levels);
- toe surgery, including including ring block with local anesthesia and wedge resection of the nail bed and total ablation of the nail;
- dermatologic surgery, including cutting, suturing, and removal of sebaceous cysts, lipomas, perianal hematomas, and skin tags.

Harvey, the cardiology patient simulator

Harvey is a teaching device that provides a comprehensive cardiology curriculum by realistically simulating 27 common and rare cardiac conditions. The physical findings programmed in Harvey for each disease include blood pressure, bilateral jugular venous pulses, bilateral carotid and peripheral arterial pulses, precordial impulses in six different areas and auscultatory events. The latter are heard in the four classic auscultatory areas, are synchronized with the pulses and vary with respiration when appropriate.

Harvey has been subjected to rigorous testing to establish its educational efficacy. The most comprehensive evaluation of any simulation technology was the multicenter study of Harvey sponsored by the National Heart, Lung, and Blood Institute. (Ewy et al., 1987). It involved 208 senior medical students at five medical schools. Fourth-year medical students who used the Cardiology Patient Simulator (CPS) during their cardiology elective performed significantly better than the non-CPS-trained group, who learned in the traditional manner from real patients. This was true not only on the CPS skills post-test (p < 0.001), but also on the live patient skills post-test (p < 0.03). In addition, there was no statistically significant difference in the way patients perceived the professional behavior of CPS-trained and non-CPS-trained students. The latter data address the concern chat simulators may negatively impact physician behavior. In another study involving more than 200 second-year medical students at the University of Michigan, incorporation of Harvey into a required physical skills course significantly improved overall cardiac examination skills as measured by the bedside skills in cardiology (Issenberg, Petrusa et al., 1999). Similar results occurred in a similar recent study involving second- and third-year internal medicine residents (Issenberg et al., 2000).

In addition to its use as an educational cool, Harvey has been used as a systematic and objective tool for testing bedside cardiovascular examination skills (Ewy et al., 1987; Jones et al., 1997; Wooliscroft et al., 1987; Gaskin et al., 2000). Testing with simulators such as Harvey is actually more effective than testing with actual patients. With a simulator, there is complete control over the specific task selected, e.g. a bedside cardiac exam, as well as the complexity of the task. Exact validation of ‘patient’ findings leads to a standardized and more-objective skills-testing process. The proven value of ‘Harvey’ as an educational tool has resulted in the recent suggestion by the American College of Cardiology Task Force on Education (Gregoratos and Miller, 1999) chat ‘Harvey’ should be integrated into the day-to-day teaching of clinical cardiology.

Computer-aided instruction: CD-ROM-based software

Computer-aided instruction (CAI) appears to be an ideal method for teaching a cote of material repetitively. CAI programs allow for an interactive educational process, requiring active involvement by the student or house off cett in thé learning process. In addition, the students are able to run the programs individually, at times convenient to them without the need for direct faculty supervision. Currently, there are hundreds of CAI CD-ROM programs available for learners at all levels in many areas of interest. These include programs that teach radiology and ECG interpretation, advanced cardiac life support, procedure skills and physical diagnosis techniques.

UMedic, Multimedia Computer System (MCS)

The UMedic MCS has been developed over the last 15 years with multimedia features chat include computer and video graphics and réal-time digitized video and audio. Fifteen patient-centered case based programs comprise a comprehensive generalist curriculum in cardiology. Its structure and content have been described elsewhere (Waugh et al., 1995; Issenberg, McGaghie et al., 1999).

A recent multicenter study demonstrated chat UMedic could be integrated into the entire four-year medical school curriculum (Petrusa et al., 1999). A total of 1586 students at six medical schools completed 6131 programs and rated thé educational value of thé system favorably compared with other learning materials. The study resulted in a recommended four-year curriculum plan for the UMedic system. Valid pré- and post-tests were then created to measure outcomes in bedside skills (Issenberg et al., 1998) and were used in an additional multicenter cohort study involving senior medical students at five institutions that compared thé UMedic system with traditional methods for teaching bedside skills in cardiology (Issenberg, Petrusa et al., 1999). In thé intervention group, UMedic modules replaced instruction in bedside skills that occurred during teaching rounds and individual patient work-ups. There was a statistically significant improvement in thé pré- to post-test scores of thé UMedic trained students compared with non-UMedic students (p < 0.001). Similar results occurred in a similar recent study involving second- and third-year internal medicine residents (Issenberg et al., 2000).

The most successful application of UMedic has been in its combined use with Harvey. In this way, thé learner has thé benefit of a large ‘patient pool’ on which to practice bedside skills along with a multimedia teaching program that provides ‘live’ faculty presentations and feedback in an interactive format. While this type of learning now Cakes place in defined areas such as clinical skills or learning resource centers, future systems will use more advanced technology to enable universal access at any time and place to chose who wish to learn or need to be tested. Undoubtedly, there systems will incorporate thé use of virtual reality.
Virtual reality

Virtual reality (VR) is a concept that is intuitively familiar and intuitively obvious to children as a consequence of video-game technology but which is far less familiar to adults who teach and practice medicine. Its roots are in the branch of computer science dedicated to artificial intelligence. At its simplest, virtual reality has been defined as, "an artificial environment which is experienced through sensory stimuli provided by a computer and in which one's actions partially determine what happens in the environment" (Merriam Webster Collegiate Dictionary, 1996).

Invasive procedures: 'See one, do one, teach one'

Teaching learners how to perform invasive medical procedures and assessing their performance is a challenging task. Traditionally, learners have observed more experienced physicians performing a procedure. After a brief apprenticeship, supplemented by reading textbooks and occasional practice on cadavers, the learner is then allowed to begin doing portions of the procedure on patients under the tutelage of the mentor. This process is inefficient and inevitably leads to considerable anxiety on the part of the learner, die mentor and at times even the patient.

Thoracentesis, for example, is a common and relatively straightforward procedure in which a needle is passed through the chest cavity to allow drainage of pleural fluid surrounding the lung for diagnostic and/or therapeutic purposes. Typically, a second-year medicine resident will demonstrate the procedure for a first-year resident with the implied promise that the next time a patient on their service requires the procedure, the first-year resident will perform it with the second-year resident 'talking him or her through it'. Inevitably, after performing the procedure once or twice himself, the inexperienced teach the even more inexperienced, leading to the medical adage, 'see one, do one, teach one'.

Invasive procedures are difficult to learn because they require an understanding of complex three-dimensional anatomy and tactile skills for the manipulation of a probe (needle, scope, catheter, surgical instrument, biopsy, etc.), commonly referred to as acquiring the 'feel' for the performance of the procedure (Robb, 2000). 'Mis inherent complexity inevitably leads to a high complication rate and steep learning curve.

As students complete their formal training and enter practice, medical centers will require that they be 'credentialed' to perform a variety of procedures. Usually this requires documentation that the physician has performed a minimum number of procedures, die irait having been set in some cases by national professional bodies and in others by the local medical center credentials committee, and a written statement from the training director of the institution from which die practitioner has come certifying his/her competence to perform the procedure. For the most part such statements are qualitative; only in rare instances are they based on objective measures of assessment.

When learning to perform an invasive procedure, the learner must simultaneously correlate the clinical assessment of an ill-and possibly sedated-patient, manipulation of a probe or surgical instrument, and the three-dimensional interpretation of a two-dimensional imaging study, all the while assessing physiology or performing a therapeutic procedure. In the beginning, most learners are able to focus only on one or two of these components at a time, contributing to both risk and stress.

Virtual reality simulation systems allow learners to practice the procedure a portion at a time, without risk to a patient. These systems, if validated, could potentially also be used to assess the learners skills for certification of competence (boards, hospital credentialing, etc.) and for maintenance of skills or acquisition of new techniques once in practice.

Computer-based anatomic models

For the last decade, computer based volume renderings of the whole body and specific organs have been generated. Initial efforts used the Visible Human Project (VHP) data set, a databank of high-resolution digital anatomy of both men and women, available from the National Library of Medicine (Visible Human Project, 1999). First implemented in 1994, the VHP has given researchers access to data in multiple modalities, including X-ray-based computed tomography (CT) and magnetic resonance imaging (MRI). These anatomic models are remarkably lifelike, and demonstrate realistic surface textures.

Virtual endoscopy

Simply viewing the surface of an anatomic model, although visually pleasing in an artistic sense, accomplishes little. Physicians wish to look inside the body, a concept first dramatized in the 1966 movie Fantastic Voyage (Fantastic Voyage, 1966). In that movie a physician suspected foul play when a diplomat became ill. He introduced a miniaturized submarine into die diplomat's body to make a diagnosis. In the 21st century virtual endoscopy systems allow the learner to see examples of normal patients and those with disease so that the student is able to anticipate how tissues will appear at the actual physical endoscopy. If the patient model is constructed using graphical data from an actual patient's imaging data (CT/MRI, etc.), die virtual endoscopy bas the potential to replace the invasive procedure for diagnosis. And if die procedure to be performed is therapeutic, one could rehearse the therapeutic procedure on a VR Simulator prior to performing the identical procedure on the patient. This would be of particular value when unusual or particularly challenging cases are encountered.

In many instances only the spatial or surface characteristics of pathology are required (e.g. ulcer, coronary obstruction, etc.), but virtual techniques currently cannot replace physical biopsy when pathological examination of tissue is required (Blezek & Robb, 1997). This may change in the near future. Characterization of tissues by MRI, ultrasound and other techniques is progressing rapidly (Satava & Robb, 1997). benign tissues may be differentiated from malignant ones in the future based on their surface characteristics as assessed by MRI.

Touch, feel and haptics

Haptics, the study of touch, allows the incorporation of tactile stimuli into VR systems allowing the learner to obtain
achieved with sensors that monitor insertion and rotation of appropriate anatomic models. Tracking of scope motions is designed to accept proxy bronchoscopes, sigmoidoscopes, and cheaper.

To illustrate the use of such devices, consider the difficulty of teaching a learner to perform deep nerve block techniques. The delivery of local anesthetics to the spinal nerves or die deep plexuses, such as the needle, for relief of pain is the epitome of the learner having to get die ‘feel’. The teacher demonstrates and explains that as the needle passes through skin one feels a ‘pop’ as the resistance of the skin is overcome. Passage of the needle through the paraspinal muscles engenders less resistance. One has to be careful not to strike either the kidney which would feel ‘firm’ or the vertebrae which would be ‘hard’. As the needle approaches the descending thoracic aorta the ‘pulsations’ can be felt on the tip of the needle which is tien directed away toward die celiac plexus.

If one mounts a force transducer on a needle and passes it through the unembalmed tissues of a cadaver on the saure path discussed above, one can directly measure the force required to overcome the resistance of each structure. Delivering those sequential forces to the learner using die force-feedback device, a virtual needle, allows the learner to experience how passage of the needle into a patient feels (Martin et al., 1999). Others have calculated die relative densities of tissues using the Houndsfield units from CT scans and tien have assigned relative forces to various tissues to achieve the saure end (Satava & Jones, 1999).

Current state-of-the-art virtual simulators

Initial VR simulation systems were crude, but improved rapidly as the speed and capacity of computers increased. These newer systems, while much more realistic in simulating die experience, were prohibitive at most medical centers because of their high cost. Recently, a more affordable VR simulator was developed to provide multiple uses in a single unit. ‘Me PreOp Endoscopic Simulator (HT Medical Systems, Gaithersberg, MD) is a realistic training simulation system that integrates force feedback, multimedia, and 3D graphics on a personal computer (Tasto et al., 2000).

The PreOp simulator comprises a computer, a display monitor and an AccuTouch Endoscopic Interface Device that consists of a proxy endoscope that looks like a real endoscope and is electrically connected to the second part of the interface device, a robotic mannequin into which die endoscope can be inserted. Various sensors track the state of the system and send this information back to die host computer. The simulation uses this information to compute appropriate visual and tactile responses to the motions imparted by the user. These responses are transmitted to the user through visual, audio and haptic modalities, creating die illusion for the user that he/she is inserting the endoscope into a real patient. The robotic mannequin has been designed to accept proxy bronchoscopes, sigmoidoscopes, colonoscopes, gastroscopes and ureteroscopes through the appropriate anatomic models. Tracking of scope motions is achieved with sensors that monitor insertion and rotation of the scope tube, while electrical actuators provide translational and/or rotational force feedback based on the state of the endoscopy simulation.

Initial results of studies to assess the effectiveness of this system in simulating bronchoscopies have shown that the die device can differentiate experts (defined as individuals who performed over 500 bronchoscopies) from those with intermediate experience (defined as individuals who performed more than 25 bronchoscopies but fewer than 25) or beginners (defined as individuals with no experience in performing a bronchoscopy) (Mehta et al., 2000). Experts performed the procedure in a significantly shorter period of time and with fewer mistakes (e.g., ‘collisions’ of scope against mucosa wall) than the intermediate and beginner groups.

In an era where the numbers of skilled teachers are declining and pressures to increase patient volumes are increasing, fewer mentors are available. VR simulation systems have die potential to greatly improve the training of learners at all levels in various fields of medicine. The saure technology that simulates a bronchoscopy can be used to simulate an ophthalmologic, neurologic or cardiovascular physical examination. The potential advantage of these systems compared with die current method for testing and certification, including written and oral examinations, is that they allow die examinee to demonstrate clinical skills in a controlled clinical environment while still exhibiting cognitive and language skills (Gaba et al., 1998).

Discussion

Despite the availability of devices with advanced simulation technology designed specifically for the instruction and assessment of medical students and physicians, too many medical schools fail to employ such devices to teach and evaluate learners’ skills (Kassebaum & Eaglen, 1999). The presence of these tools is not enough. Evidence-based outcomes must guide medical educators who are willing to effect change.

In an article in the End-of-the-Millennium Special Issue of Scientific American, entitled ‘The Unexpected Science to Come’, Sir John Maddox wrote, ‘The most important discoveries of the next 50 years are likely to be ones of which we cannot now even conceive’ (Maddox, 1999). Foreseeing what new technologies will be in use in the year 2020, far less predicting their impact on the ‘day-to-day practice of medicine and its teaching, is an exercise fraught with danger. The compilation of essays by the Pulitzer Prize-winning Richard Rhodes, entitled ‘Visions of Technology’, is replete with examples of predictions that, in retrospect, missed the mark significantly. Some predictions, however, are remarkably prescient. One essay points out that, over the past 100 years, die technological status of die world as a whole advanced at a roughly exponential rate, doubling every 20 years (Rhodes, 1999).

Four general predictions may be offered on the impact of simulation and virtual reality technology on the practice of medicine and medical education in 2020:

1. Anything to do with the human body in sickness and in health that is ‘digitizable’—and thus ‘storable’, ‘manipulable’, ‘clonable’, ‘transmissible’—will be, and the computers involved will become faster, smaller and cheaper.
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wrote, "The art of medicine is to be learned only by experi-
tences in performance observed for normal adults". He also
ferences between individuals, from novice to champion, "are among the largest reproducible differences
in performance observed for normal adults". He also
suggests that similar large differences would be expected in
other domains of expertise (including medicine), in which there is a long period of education followed by an apprenticeship.

The most important identifiable factor separating the elite performer of skills from others is the amount of 'deliberate practice'. This includes practice undertaken over a long period of time in order to attain excellence, as well as the amount of ongoing effort required to maintain it. Deliberate practice has been defined as the opportunity to tackle "a well-defined task with an appropriate difficulty level for the particular individual, informative feedback, and opportunities for repetition and corrections of errors" (Ericsson et al., 1993).

In the early part of the last century, Sir William Osler wrote, "The art of medicine is to be learned only by experience, 'tis not an inheritance; it cannot be revealed. Learn to sec, learn to hear, learn to feel, learn to smell, and know that by practice alone can you become expert" (Osler, 1919).

However, it is well known Chat, during both undergraduate and postgraduate medical training, there is an inherent capriciousness in regard to opportunities to gain deliberate practice in learning new skills or honing old ones. Even when opportunities to practice specific skills do occur, there is often no informative feedback or opportunities for repetition or correction. The problem in medical education is that the subjects necessary to 'deliberately practice upon' are human beings, with all their diversity and variability.

Simulations and virtual reality hold out the promise of unlimited access to deliberate practice as part of skills training. As the skills required for the practice of invasive medicine become more numerous and more complex, such access to practice and rehearsal will become more essential.

Technology and medical education: what does the future hold?

The year 2020 seems such a long time away, yet 1980 seems just a short time ago! When learning from the past to predict the future of medical education, one thing is sure: medical educators are not 'early adopters'. It took 30 years for problem-based learning (PBL) to truly become mainstream in the field. The need to inculcate a culture of lifelong learning is more talked about than practiced, and some medical educators still think that OSCE is an organization of oil-producing nations. So we will take the easy way out in compiling our predictions regarding the impact of technology on the future face of medical education. Although we use the word 'will' in making the following predictions, we are, in truth, really suggesting what should happen.

The undergraduate curriculum will be unrecognizable in the traditional sense since the stages will be marked less by organ/system or discipline-based blocks or rotations, and more by the attainment of measurable outcomes, the rate of which will vary from student to student. The merging of educational strategies such as PBL and self-directed learning with the just-in-time availability of information through IT and the use of cumulative learning portfolios of practical and clinical experiences as a major assessment tool will allow, within limits, students to progress through the curriculum at their own pace.

Increasingly, in the early years, the acquisition of knowledge and understanding will be through self-directed (but outcomes driven) learning. Information to facilitate that learning will be delivered over the Internet, using fast broadband 'pipes' to transmit text, audio, video, chat groups and, where appropriate for understanding, simulations and virtual reality. All of this will be enhanced by live group discussion and tutor input.

Realizing that, despite regional, national and international differences in core curriculum content, there are overlapping commonalities, a growing amount of the learning material required for core learning will be shared between medical schools and delivered over the Internet. In some cases, these would be single learning items such as texts and interactive simulations. In other cases, whole modules or even blocks will be used communally.

In the later years, cumulative electronic learning portfolios will map each individual student's progress in meeting the learning outcomes. They will ensure that all students are exposed to patients illustrating the key common problems faced by primary-care physicians and that the students have seen the 'prototype' cases around which clinical problem solving is based.

Appropriate use of these learning portfolios will also ensure that the underlying anatomical and pathophysiological concepts are reinforced as clinical cases are encountered. This will require more basic science input into the later years of the curriculum.

The real power of VR simulations is their potential widespread accessibility. Simulations, with all their interactivity, will be widely available over the Internet. For many, the limiting factor will be the availability of the hardware - 'front end'- the controls that allow the operator to interact appropriately with the simulation. For some simulations a standardized front end will be
compassionate care. Ensuring that the latter occurs is the key role of new technologies and better skills training of doctors can free up time for meaningful patient care. In some cases, the hardware may be inexpensive enough to be purchased by individuals, allowing them to deliberately practice or rehearse anywhere they want, even at home with the kids. Regular upgrading of the skills appropriate to their practice using simulators will be a normal part of continuing professional development (i.e. continuing medical education, or CME)—even for those practicing in the community. And finally, do not forget gaming and the gamers, who, more than any other group, brought simulations into the mainstream. If there is any challenge to their manual and decision-making skills out there, they will avant to try it and compete with others. And there will be someone out there who will avant to sell it to them. Look to see many complex surgical or procedural simulations available in game arcades and even at home. Medical simulations will be seen as the ultimate game. Just think about it: some 15-year-old challenging a cardiac surgeon in a by-pass operation simulation—winning! It is inevitable, and may be appropriately humiliating.

Conclusion

There are those who will see the future elucidated above as an Orwellian nightmare of technology's dehumanizing face. They will see only a dark picture of chips, bits, bytes, pixels and avatars obscuring the human tragedy of illness and disease and the anguish they cause. But they will be wrong.

Doctors better trained in basic clinical skills and with on-demand opportunities to 'deliberately practice' to maintain them, will, as did our young student, Peter Smith, come to realize that such skills are the gateway to the appropriate ordering of tests and images. This will actually diminish the need for the unnecessary intrusion of diagnostic technology into the patient's life. Such imaging technologies, despite their tendency to reveal the presence of unknown benign lesions and raise patients' fears falsely, still, on balance, advance the early diagnosis of less benign but curable pathologies. Simulation and virtual-reality technology have the ability to allow practice and rehearsal of invasive procedures specific to an individual patient's anatomy and pathology, thus saving the patient unnecessary surgical exploration and diminishing the risk of insertion, ablation or incision errors.

Finally, one thing is certain. Although there will be advances in the medical sciences and technology over the next 20 years "of which we cannot now even conceive", the innate nature of humankind will not change. Illness, real or imagined, will still engender fear and anxiety and require explanation, reassurance and succor. Earlier and more efficient diagnosis brought about by better diagnostic technologies and better skills training of doctors can free up more of our time for communication, discussion and compassionate care. Ensuring that the latter occurs is the real challenge. The technology has proven itself.

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References


FANTASTIC VOYAGE, (1966), directed by Richard Fleischer.


JoNEs, J.S., HuNT, S.J., CARLsoN, S.A. & SEAmoN, J.P. (1997) The norm, as gaming joysticks and ports have become. For the more complex procedures special hardware will be necessary. Such hardware will be relatively inexpensive and can and should be scattered around clinical facilities and accessible round the clock so that on-demand skills training, rehearsal or updating is available. In some cases, the hardware may be inexpensive enough to be purchased by individuals, allowing them to deliberately practice or rehearse anywhere they want, even at home with the kids. Regular upgrading of the skills appropriate to their practice using simulators will be a normal part of continuing professional development (i.e. continuing medical education, or CME)—even for those practicing in the community. And finally, do not forget gaming and the gamers, who, more than any other group, brought simulations into the mainstream. If there is any challenge to their manual and decision-making skills out there, they will avant to try it and compete with others. And there will be someone out there who will avant to sell it to them. Look to see many complex surgical or procedural simulations available in game arcades and even at home. Medical simulations will be seen as the ultimate game. Just think about it: some 15-year-old challenging a cardiac surgeon in a by-pass operation simulation—winning! It is inevitable, and may be appropriately humiliating.

Conclusion

There are those who will see the future elucidated above as an Orwellian nightmare of technology's dehumanizing face. They will see only a dark picture of chips, bits, bytes, pixels and avatars obscuring the human tragedy of illness and disease and the anguish they cause. But they will be wrong.

Doctors better trained in basic clinical skills and with on-demand opportunities to ‘deliberately practice’ to maintain them, will, as did our young student, Peter Smith, come to realize that such skills are the gateway to the appropriate ordering of tests and images. This will actually diminish the need for the unnecessary intrusion of diagnostic technology into the patient's life. Such imaging technologies, despite their tendency to reveal the presence of unknown benign lesions and raise patients’ fears falsely, still, on balance, advance the early diagnosis of less benign but curable pathologies. Simulation and virtual-reality technology have the ability to allow practice and rehearsal of invasive procedures specific to an individual patient’s anatomy and pathology, thus saving the patient unnecessary surgical exploration and diminishing the risk of insertion, ablation or incision errors.

Finally, one thing is certain. Although there will be advances in the medical sciences and technology over the next 20 years “of which we cannot now even conceive”, the innate nature of humankind will not change. Illness, real or imagined, will still engender fear and anxiety and require explanation, reassurance and succor. Earlier and more efficient diagnosis brought about by better diagnostic technologies and better skills training of doctors can free up more of our time for communication, discussion and compassionate care. Ensuring that the latter occurs is the real challenge. The technology has proven itself.

Notes on contributors

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simulations on health care issues

KEYWORDS: 

AIDS, change, design, family communication, long-term medical issues, medical care, research, technology, training, development, culture.
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### TABLE 3: Scenarios That Were Used in the Simulation

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Guest editorial: Twenty-five years of ABSEL research

**Simulation & Gaming,* Thousand Oaks; Mar 2001, Alan L Patz;**

**Volume:** 32  
**Issue:** 1  
**Start Page:** 18  
**ISSN:** 10468781  
**Full Text:**

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[Headnote]
The authors of the following six articles have been and continue to be leading and significant contributors to ABSEL research and to the organization itself. In fact, most are past presidents, fellows, or both. Their commitments to ABSEL’s success have included serving in all or several board of directors positions, acting as chairs and discussants at annual conferences, charting research paths for new members, and taking important positions in the publication of Simulation & Gaming. Many other similar contributors may be noted simply by reviewing ABSEL’s Web page.

As a relative newcomer joining at the beginning of ABSEL’s 14th year, I have been privileged to know and work with most of these people and enjoy the benefits of their reviews and comments on my research. Although many could and should be mentioned in this regard, only one is that of J. Bernard, “Bernie,” Keys who has been a supportive colleague over the years and who suggested this special issue. He was unable to continue as a coeditor, but his influence is clear in all that follows.

**An Overview**

The included articles vary significantly over ABSEL's landscape, and this is most desirable to grasp the general nature of the research territory. However, there are several continuous paths among them. One will be presented here.

**ABSEL’s Two Thrusts**

The Goosen, Jensen, and Wells article followed by the Graf article form a comprehensive treatment of the learning benefits of simulation and experiential exercises. Goosen et al. warn that in business administration there are often conflicting theories, and a simulation can incorporate only one in a given functional area. Therefore, simulation designers have to choose what to incorporate in their game, and it is very easy for a simulation to reflect the biases of the game designers. Equally if not more important, a prospective user of a simulation must carefully examine a simulation to determine whether a given one reflects what is desired to be taught.

Although the Graf article covers many of the same points in the experiential area, it has an interesting history that will be of importance to many readers. In fact, it is only one of three articles designed to provide a complete ABSEL proceedings background/literature search of what already has been done in the experiential learning/experiential exercise area. Although Graf covered the decade of the 1970s, Lane Kelley and William D. Bice took the 1980s, and John Butler examined the 1990s. The three articles were presented at the 1999 ABSEL conference in Philadelphia and appeared in the 1999 proceedings. Thus, in addition to the included coverage of the 1970s, interested readers may review the other two decades by accessing the 1999 proceedings.

**What Went on With Simulations?**

Continuing this historical approach with simulation algorithms, Gold and Pray take up the question of internal validity in the design and modeling of business simulations. Over
the past two decades, the ABSEL conference has been used as a way for game designers to share the algorithms embodied in their games and get feedback from the academic community.

They conclude that the published research has clearly improved the modeling of business games, that the newer games run more efficiently on microcomputers and behave rationally with results that are consistent with modern theory. Moreover, newer games embody many of the topical issues that businesses confront in the 21st century, including new product development challenges, continuous improvement and quality management issues, and human resource challenges.

In a similar vein, the Fritzsche and Burns article traces the development of marketing simulations coinciding with advances in computer technology. The technology has served as the vehicle for the growth and increasing sophistication of marketing simulations. ABSEL’s role in this development has been to serve as a conduit for the development and dissemination of concepts, ideas, and experiences via conference presentations, discussions, and publications. Many ABSEL-related developments have been incorporated in subsequent editions of existing and new simulations, and ABSEL has been the primary academic organization promoting the development and use of marketing simulations.

Then, Faria takes an overall approach to the entire simulation area. More than 100 gaming articles are reviewed covering such research topic areas as the changing nature of business games, correlates of simulation game performance, the effectiveness of business games in strategic management courses, a comparison of business gaming to other teaching methods, and the cognitive and behavioral nature of learning through business simulation games.

The Future

The Patz, Keys, and Cannon article closes this issue with a “Merlin” empirical study of ABSEL’s future in the year 2005 and how to get from here to there. Several themes emerge.

Among them are that ABSEL is poised for prominence because of the growing importance of pedagogical research. Pedagogical research is aimed at producing results—not at advancing the current fashionable and almost always fleeting notions of an elite at a local university or editorial staff of a widely distributed journal.

Second, with each passing year, ABSEL becomes more international in its membership and outlooks. This will enhance our current inventory of simulation and experiential exercises as well as providing an avenue for ABSEL-CO, a for-profit company.

Last, ABSEL will take a key leadership position in pedagogy by student-centered education models. The products, principles, and research consultation that will make this a reality are covered in the final paragraphs of the article.

[Author note]

-Alan L. Patz Guest Editor