CAN THE COMPUTER MAKE IT BETTER?

IF THE SUBJECT IS MEDICAL EDUCATION, THE ANSWER SEEMS TO BE A RESOUNDING "YES!"

By Jane Myers

Invoking "Moore's Law" is a popular way to illustrate the fabulous pace of the information technology revolution. In the mid-1960s, Gordon Moore, the semiconductor engineer who later co-founded Intel, gave a talk in which he introduced the concept that came to be named after him: i.e., the amount of information that could be stored on a given amount of silicon had roughly doubled every year since the technology was invented.

Thirty-five years later, the pace of change in the world of information hasn't slowed perceptibly. And in the world of medical education, it's just heating up. Casey White, director of the University of Michigan Medical School's Learning Resource Center, could write her own version of Moore's Law: the number of students and faculty demanding more Internet- and Web-based learning and teaching doubles every time she turns around. Some might find this daunting. But it is Casey White's own version of paradise. "I want to see them lined up out there in their white coats asking for more," she says with the enthusiasm of a true believer. A native New Yorker who still talks at the speed of a subway passenger determined to finish a complicated explanation before the next stop, White is the right woman in the right place at the right time.

A would-be novelist, she decided 18 years ago that the challenge of helping medical faculty with the development of curriculum was every bit as creative as writing fiction. The addition of high-tech to the mix has made it even more so. And there are nail-biting days that even Stephen King would appreciate—like the morning somebody mistakenly turned off a server when a group of medical students was taking an exam on-line. "I handed out M&Ms that day," she says.

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>
> —JOE FANTONE, ASSOCIATE DEAN FOR MEDICAL EDUCATION

Casey White with second-year medical student Aashish Didwania.

Such momentary glitches with their accompanying high anxiety don't dampen the ardor of medical students for what Casey White is trying to accomplish. Mere infants in the late 1970s when computers began transforming the way people manage information, they are among that generation that views computers, cell phones, pagers, fax machines and TVs as something akin to extensions of the human body. For them, the only question is, "When do we get more?"

White's biggest challenge these days is helping faculty find the time to create the Web-based materials they envision for their own teaching futures. "'Busy' is a big factor," she says. "Our faculty are so, so, so, so busy. They want to be creative; they want to find new and exciting ways of delivering their courses and clerkships. But the time pressures that interfere with the creative impulse are enormous for them."

Associate Dean for Medical Education Joseph C. Fantone III, M.D., believes that students would benefit from less time in lecture halls, and he is encouraging faculty to think about ways to make medical learning more interactive. "We know that students must become lifelong learners," he says, "well attuned to independent learning. The web, because of its accessibility and interactivity, may be one of the best new avenues available to us." The quest is always for those magical "teachable moments," a phrase used by Roland "Red" Hiss, (M.D. 1957, Residency 1964, Hematology Fellowship, 1966), professor of internal medicine and chair of the Department of Medical Education, to describe those precious instances when everything clicks and the student discovers what he or she really wants to know and will thus probably remember forever.

For many faculty, the realistic way to begin is one small step at a time. When the students in Professor of Pediatrics Mary Ellen Bozynski's clerkship asked for more time to study pediatric X-rays, White's staff helped her put the X-rays up on a Web site. The Learning Resource Center now has a "Faculty Development Station" where faculty can enhance and upgrade their teaching materials and gain ideas for original computer-based materials.

Last year when Casey White set up two new express e-mail stations where students could quickly sign on to check their e-mail, the stations were an instant hit. "They lined up out there in their winter coats at 7:45 a.m, laughing as they read their messages," she says, "and before long they were asking for more stations." In addition to their e-mail, students can check exam scores and their ranking among their classmates, a kind of high-tech reassurance in the competitive world of medical learning. "They always want to know how they're doing," White says, " and computers are a great way to give them their exam scores quickly, along with a great deal of other information they want and need." White credits Dean Allen Lichter for understanding the importance of technology in medical education today and for providing the resources, such as assistance from the School's Information Systems staff, that make her work possible.

The Medical School, of course, is not alone in finding that ways of learning and communicating are evolving with the addition of computers and the Web to the educational landscape. Casey White has also been grateful to have the resources of the University's Office of Information Technology in the Instructional Technology Division (known around campus as ITD) available to her with their technical knowledge and their awareness of what is happening elsewhere on campus." It gives us access to a higher level of expertise and helps us avoid reinventing the wheel," she says. "At some point we need to be able to look across campus and ask, 'Has this been done before?'" ➤

Last year in a pilot program half of the students in the first-year class took their quizzes on-line, a step proposed by the faculty to give students more flexibility time-wise in taking their quizzes. For image-heavy disciplines like histology, the computer-based format has particularly high potential. The pilot was a popular success with both students and faculty, and this fall, all first-year students will be taking their quizzes on-line. Nationally, more examinations are going on-line as well. The United States Medical Licensure Examinations, a three-step series of exams students must pass to obtain a license to practice medicine, are now computer-based.

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For White, getting it right is her main goal these days. "We want to be sure what we're offering the students meets a high quality standard," she says. "We don't want to do anything that turns people off; we don't want to deliver any duds." The quality of video on the Web, for instance, still isn't great. But as it improves, White envisions "the perfect cardiology exam or a psychiatric interview where you can see tiny nuances in facial expressions."

Does the advent of the computer mean less personalized teaching? "Students and faculty interacting with each other and with patients will never go away," White says. "It's really a matter of balance, finding ways to deliver all the things it takes to educate a physician or medical scientist these days." Given the amount of information that is out there now, computers and the Web are in many ways the salvation of medical education. "There was too much information to digest when I was a student," noted Dean Allen Lichter in a speech recently. "And now there's many times more."

Certain kinds of technology to support medicine are not new at all: X-rays, for instance, were discovered by German physics professor Karl Wilhelm Röntgen more than a century ago and were used for clinical purposes by 1896. But Röntgen's X-rays and today's digital imagery are about as far apart as rock-scratchings and smoke signals are from electronic communications.

In our lifetimes alone, the leap forward has been dramatic. Reed Dunnick, M.D., chair of the Department of Radiology and the Fred Jenner Hodges Professor of Radiology, remembers the first CT scans in the late 1960s that over a 10-day period generated an image block by block. That same image, much improved, is now not only generated in seconds but can be instantly transmitted around the U-M Health System or around the world—allowing extremely skilled subspecialists to view the images.

The extraordinarily detailed views of the human body provided by computerized axial tomography and magnetic resonance imagery are not only a boon for the practicing physician and the patient, but for medical students as well. Dunnick foresees the day when cadavers will mostly be superseded for the teaching of anatomy by the almost limitless range of views of the human body provided by CT and MR images.

The importance of technology in the teaching of radiology is underscored by the fact that Dunnick last year appointed an associate chair for information technology, Professor James H. Ellis, M.D. In a world where the practice of medicine itself is increasingly based on digital imagery, with three-dimensional fluoroscopic image-guided interventions the wave of the very near future—including such procedures as putting a stent in an intracranial blood vessel or removing renal stones—technology is no longer an optional part of medical education but an essential part. ➤

A medical student performs surgery on a life-like human patient simulator, which not only looks eerily real, but also functions, responds and can be monitored like a real patient. The goggles worn by the student and video projections onto screens surrounding the operating table are used to mimic the distractions, noise and competing priorities of an emergency situation.

Radiology Chair Reed Dunnick with Richard Urbancic, first-year resident in radiology.

The "Cave:"

a place where virtual life and virtual death offer swift and unforgettable lessons to the physician in training

There's no Alice, but immersive virtual reality is nevertheless enough of a wonderland to have its creators grinning like the Cheshire Cat. It's a world where things are not as they seem but where the "reality" created by technology is more useful than the real thing — where a human being that bleeds fake blood and goes into fake shock can provide invaluable insights to a medical student or a practicing physician in a way never before possible. For Dag von Lubitz, Ph.D., a scientist who is director of the Emergency Medicine Research Laboratories and participant in an unusual enterprise known as a virtual reality "cave," it's at least as mind-bending as Alice's experiences after she tumbled down the rabbit hole. (The word "cave" is actually an acronym for "cave automated virtual environment." The basic product is licensed by Pyramid Systems and uses Silicon Graphics computer technology.)

"The possibilities are limitless," says von Lubitz, of a six-month-old research effort in the Department of Emergency Medicine. "We ourselves, within this little group of enthusiasts, are discovering new frontiers almost daily."

"Immersive virtual reality" results from the fusion of two technologies: one that makes a robot-like plastic and wire invention act very much like a living, breathing human being and another that, via a complex set of goggles, infuses a make-believe operating room with enough high-tech computer data that it begins to look and feel very much like the real thing. The result is a whole that's greater than the sum of its parts, what von Lubitz calls "a hyper-rich environment."

The team that's doing all this, which includes engineers, computer specialists, emergency physicians and von Lubitz himself, is as impressive as the results it's producing. Von Lubitz, who holds degrees in neuropathology and marine biology, believes it could exist only at a place like Michigan because of the presence of academic stars in so many disciplines and an underlying philosophy that nourishes collaboration. "It wouldn't happen, to my mind, anywhere else," he says. "We could serve as a model of how an interdisciplinary team should work."

Members of the team include Timothy Pletcher, an information technology "genius," as von Lubitz describes him; Klaus Peter Beier, Ph.D., a naval architect and world recognized authority on virtual reality; William H. Wilkerson, M.D., clinical assistant professor of emergency medicine, James A. Freer, M.D., clinical assistant professor of emergency medicine, and David J. Treloar, M.D., clinical assistant professor of pediatrics and communicable diseases and clinical assistant professor of emergency medicine — all senior emergency medicine physicians. "The beauty of this team is that it needs no leader because we communicate so well," von Lubitz says. "But the critical and absolutely unique achievement of our team is the fact that we merged these two technologies into a seamless entity," he adds. "We created what we now call a hyper-rich environment, where we can expand the tactile, visual combination of learning that the patient simulator gives you with any type of medical information available to you by any electronic means."

"There are about 60 universities worldwide that are using human patient simulation in anesthesiology training," says von Lubitz. "We are the first to make emergency medicine and trauma medicine a primary target, exposing students to elements that are destructive, elements that are stressful, elements that increase the adrenaline rush and decrease the amount of, shall we say, readily available knowledge. All that comes with experience, but experience can be rather costly in terms of poor performance. This system allows you, for the first time, to combine a number of elements that you have in real life, and drop your trainee into hot water and say, 'Deal with it, that's real life!'"

Having once served as a junior medical officer on a military ship, von Lubitz is familiar with operating under adverse conditions. "Many years ago, I was on a minesweeper in the North Sea and one of the seamen tripped on the threshold of a hatch, flew headlong along the passageway and broke his forearm," he says. "It was the simplest fracture, but we were in a very nasty gale with mountainous seas. The ship behaved like a totally unpredictable express elevator and it took me one and a half hours to deal with the problem. That experience has stayed with me forever because I was not prepared for it. You don't have any type of training that prepares you for unpredictable, sudden motions of the floor, smells that are excruciatingly unpleasant." If von Lubitz has his way, virtual reality will soon allow students to experience every kind of real-life horror in the virtual reality "cave," facing useful challenges never possible to experience in this way before.

"It's completely unconventional," Tim Pletcher says, "but it's also very persuasive. When you put a student into this environment, where the learning takes place by feeling, by seeing, you quickly see that we learn best by using our senses. You can see that a student learns more about pharmacology by seeing the physiological response of the human patient simulator than by reading five chapters in a book of pharmacology."

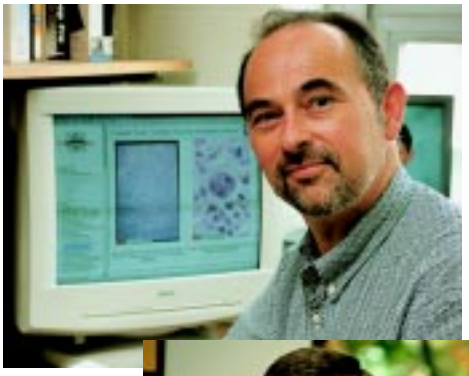
Because virtual reality is so real it has dramatic implications for research as well as for teaching. "We've done a couple of experiments where we've simply repeated animal experiments on the simulators to see what happens, and our results were within 10 to 15 percent of the lab results," von Lubitz says. "If it turns out we can use them as predictors of bench research, that could mean massive savings in expenses on research animals, and also saving a number of research animals."

The virtual patient in von Lubitz's "cave" may also offer whole new ways of testing the competence of medical students. Instead of a paper exam, he or she might be presented with a "virtual" elderly, slightly obese woman with elevated blood pressure who has just fallen in the street. "Based on information from the triage nurse or EMT, the doctor has to start managing the case," says von Lubitz. "That simulator is very, very physiological. You either do it right or you do it wrong and if you do it wrong, you may well kill the patient, which obviously terminates the examination."

Von Lubitz, who gives great credit to William Barsan, chair of the Department of Emergency Medicine, for his courage in supporting such an unlikely venture and to Jocelyn DeWitt, Ph.D., director of the Hospital's information technology, delights at the thought of all the possiblities that lie ahead in immersive virtual reality. "The intellectual atmosphere of this department is absolutely unprecedented," he says. "Great discoveries lie ahead. Alice? She would have loved it."

"The curve is steadily upward," Dunnick says, standing in a darkened film-viewing and CT scanning room down the hall from his office that these days has the look of a major television network studio: banks of monitors with physicians peering into them while the "production" behind the glassed window is the patient who, with a single breathhold, can have his or her body scanned from neck to pelvis, creating stored images of amazing complexity that can be magnified, viewed laterally or longitudinally, made lighter and darker, stored for comparison a week later with new images, or sent around the globe.

> "THE WEB OFFERS A RICH TAPESTRY OF TOOLS FOR VISUAL CONTENT," STOOLMAN SAYS. "WE'RE JUST BEGINNING TO TAP IT."



> WEB-BASED MATERIALS, WITH THEIR WIDE ACCESSIBILITY, HELP TO CREATE ELECTRONIC BRIDGES AND PROVIDE A WAY TO REVIEW MATERIALS AS MANY TIMES AS NEEDED, WHICH GRUPPEN SEES AS A GREAT PLUS.

Not surprisingly, it is in the image-heavy specialties like radiology and pathology that the most effort has been made to date to integrate Web-based learning into the curriculum. Associate Professor of Pathology Lloyd Stoolman, M.D., was chosen as a 1999 Laureate and finalist in the highly competitive "Education and Academia" category of the Computerworld Smithsonian Awards this year for his work in developing Web-based courseware called "The Virtual Microscope," separate versions of which are being used by second-year medical students and by dental students. Putting microscopic images on the Web turns out to be a real boon for many students. Such "slides" can be accessed at any time. They can be looked at over and over again. They can include annotations to highlight key structural features. Clues can be embedded in the images so that the student, rather than being directed by static arrow, can be allowed to explore the slide and use his or her detective skills to discover the nature of the underlying disease process.

Stoolman's Web-based "virtual microscope," which uses the FlashPix image format and the Live Picture Image Server technology, is, in his view and that of many of his students, a fine addition to the arsenal of teaching tools. "Great," "nice," "awesome," "cool," "excellent," "perfect," "very helpful," are some of the adjectives students have used in anonymous evaluations.

"The Web offers a rich tapestry of tools for visual content," Stoolman says. "We're just beginning to tap it." Like all the pioneers in this area, Stoolman has had his frustrations with the limitations of a technology still evolving. With higher screen resolutions, faster CPU's, and higher Internet speeds, much greater advances will be possible. But he already feels the great satisfaction of a teacher who has found yet another way to engage his students in their quest for competence. And he applauds the efforts of his many colleagues who recognize the virtues of putting visual content on the Web and the University's Intranet. These innovators include: Richard Lieberman, M.D. (Departments of Pathology and OB/GYN), Professor of Pathology Andrew Flint, M.D., Associate Professors of Pathology Paul Killen and Joel Greenson and Professors of Anatomy Donald MacCallum and Kate Barald, who have also produced Web-based annotated atlases.

Is putting material onto a computer just a matter of going from ink to digital, from peering into a microscope to staring at a computer screen? Just a fad, perhaps? Faculty and students overjoyed by the possibilities of technology aren't asking such questions any longer.

But for scholars like Larry D. Gruppen, Ph.D., associate professor of medical education, and Red Hiss, who have spent their careers pondering the complex questions of how humans—and especially medical students—learn, the advent of new technologies hasn't changed those basic questions.

One of the most attractive elements of educational technology, in Gruppen's view, is that "it's always there, it's always the same. With only 5-7 percent of all patient care taking place in hospital settings now, the education of physicians at the residency and fellowship levels is, by necessity, much more dispersed than it once was. Web-based materials, with their wide accessibility, help to create electronic bridges and provide a way to review materials as many times as needed, which Gruppen sees as a great plus.

Still, he doesn't think we should expect instant learning. "You rarely learn one thing by one experience," he says. He's

done research on the subject of expertise and how long it takes to develop it. "What's striking is how long it takes," he notes. "Learning to play chess, to play the violin, to play the piano, to excel in any of the arts or athletics—it typically takes about 10,000 hours to become good at any of these things, and there doesn't seem to be any decent way to speed it up. How this translates to medical education is not clear, but there do seem to be some fundamental limits to how people learn that the technology cannot eliminate."

From what he has seen to date, Gruppen isn't sure that technology-based learning will be cheaper or easier. "People have found that often the cost-savings are much smaller than originally thought," he says. "You might think that a faculty member could teach 3,000 students instead of 300, but it doesn't work out that way. He has to communicate with each of those students by e-mail—and students tend to write more than they would say in person. Responding to e-mails takes a lot of time. In some of the studies undertaken by the American Educational Research Association, faculty have been very disillusioned by the time-consuming nature of e-mail."

Gruppen's research has shown that long-distance lectures hold promise. "Students generally perceive long-distance lectures as being as good as the traditional lecture," he says. "The information is often better prepared, more structured—the teacher can't just walk in with a box of slides and ramble—but you lose spontaneity, the ability to ask questions." He points to Richard Judge, clinical professor of internal medicine, as someone who has successfully integrated interpretive commentary with images in cardiology. "He's one of the best," Gruppen says. "Computers can give you much more consistency," Gruppen adds. "You can record a heart murmur, for instance. But so much depends on how the developer organizes it. In the hands of someone as skilled as Dick Judge, it can be wonderful."

Hiss, who has been involved with medical education at the University of Michigan for more than 30 years and has been chair of the Department of Medical Education since 1982, never loses sight of the fact that new technology, no matter how many bells and whistles it may have, is only part of a much bigger picture that includes curriculum development, faculty training, learning theory and behavioral change. Having helped teach the hematology sequence 35 times to 35 classes, he is no stranger to the mysteries of learning.

"Technology does give us information faster and in a more widely disseminated way," he says. "But we still have to overcome barriers of attitude. Human resistance to change is a basic barrier. Having the information come at you faster doesn't change that."

Hiss wants to wrap up his career over the next three years by producing a new model for continuing medical education, a model based on 15-20 "key points" that a physician needs to know and can apply over a year's time, and that might take 20 hours a year to absorb. But the "teachable moments" when those key points can be assimilated? Will it be at a seminar? A meeting?

Or on the Web?

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CONTACT:

Lloyd Stoolman's websites for students can be viewed at:
http://141.214.612/cyberscope631/
http://141.214.612/virtualheme98/

The Computerworld Smithsonian Innovation Website can be viewed at: http://innovate.si.edu/index.html

The complete case studies for all Computerworld Smithsonian nominees can be viewed at: http://198.49.220.47/texis/si/sc/innovate/ (Go to "Education and Academia," then "University of Michigan," then, at the bottom of the page, "More Detail.")

Faculty members featured in the above article may be reached by e-mail at the following addresses:

Mary Ellen Bozynski: maryeb@umich.edu

Reed Dunnick: rdunnick@umich.edu

Larry Gruppen: lgruppen@umich.edu

Joseph Fantone: carmine@umich.edu

Andrew Flint: aflint@umich.edu

Roland Hiss: redhiss@umich.edu

Richard Judge: rjudge@umich.edu

Casey White: bcwhite@umich.edu