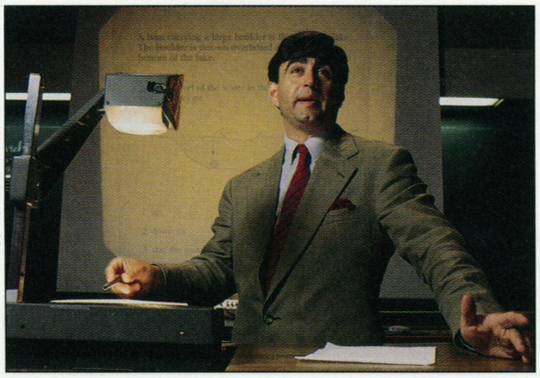
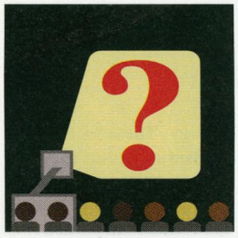


JON CHASE/HARVARD NEWS SERVICE

Quizmaster. Eric Mazur interrupts his physics lectures to give frequent "Conceptests" on an overhead computer.



there are other benefits as well. The quizzes provide quick feedback to lecturers and build self-confidence among students who grasp the concepts and explain them to others. "Just being able to explain really helps them learn it better," says Patricia Allen of Appalachian State University, who is also examining gender differences within this peer-instruction approach.

And from observing his students in action, Mazur has learned that undergrads can outshine their professors in the classroom. "A student who understands [a concept] is sometimes better at explaining it to others than I am," he says.

–John Travis

Turning Students On by Simulating the Arcane

Carnegie Mellon University physicist Bruce Sherwood could never figure out how to teach Ampere's law, which explains the relationship between magnetic fields and electric currents. "You could lecture until you were blue in the face, but the students just didn't get it," Sherwood said about his introductory course in electricity and magnetism for science majors. So Sherwood turned to something his students were sure to understand.

The computer. With the help of an overhead screen that makes his monitor visible to students, Sherwood uses a mouse to explore the simulated magnetic and electric fields generated by a current-carrying wire—and how those fields are altered by other distant charges. The result, called EM Field, gives students an intuitive feel for how the formal, calculus-based laws of physics work in the real world. It has also raised test scores. "With this tool, we've just cut through a big problem students always have visualizing electric and magnetic fields," says Sherwood, whose EM Field was a winner in the 1991 Computers in Physics educational software contest.

In classrooms and labs in universities across the country, more and more students are pointing and clicking their way through explorations illustrating the abstract laws of physics or the three-dimensional structure of proteins. They are also tutoring themselves in chemistry and calculus. These new computer tools are even replacing some of the time students spend in traditional wet labs. "It has totally transformed the way we teach introductory chemistry," says University of Illinois, Urbana-Champaign, chemist Stanley G. Smith.

Students starting Chemistry 101 at Illinois walk into a "lab" with 80 personal computers and workstations and log on to the campus network. Within seconds, they're given a choice of lessons—including videodiscs of laboratory experiments that they can control. One experiment, for example, allows them to explore different chemical reactions—and shows them the results. Students can tell the computer to add aluminum to a beaker of bromine and watch the solution flare up into a fiery reaction on their screen. "We film it from the student's point of view," says Smith. "It's what you'd see if you were doing it yourself in the lab."

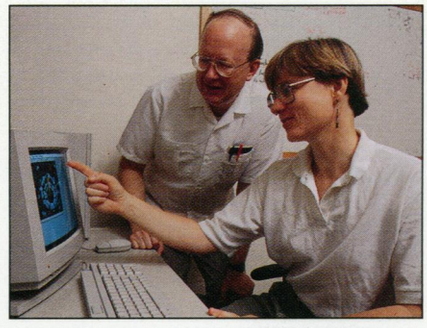
The computer has cut in half the amount of time students spend in the wet lab. "This replaces lab experiments that are too expensive, too hazardous, too complex, too time-consuming," says Smith. It also gives students a chance to set their own schedules. "I think it's great, because I could work very slowly until I understood it," says Jenny Schwab, a sophomore at Illinois. "It's not the most exciting way to spend a weekend, but I could work at my own pace." Adds Smith, "You can now do your chemistry from the library."

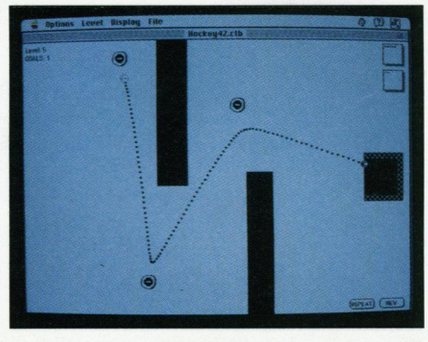
Computers can also save students time. A new "Tech Commander" computer system at Vanderbilt University in Nashville, Tennessee, is helping 260 premed and biology students reduce the number of errors they make in a molecular biology lab course. They preview experiments on their computer, looking at video images of their electrophoresis gels or microscope specimens, says Vanderbilt systems analyst Steve Garrison. "It doesn't replace the lab, but it makes them more efficient."

The best computer software speeds up the learning process by showing students real-world applications of the abstract concepts they learn about in lectures and textbooks. Many physics students, for example, can solve the calculus-based equations at the heart of many laws of nature, but they lack an intuitive feel for how they work. "We want to construct an environment where they can do much of what real scientists do—apply a few fundamental principles to a broad range of phenomena," says Sherwood, who has written several prize-winning physics software programs with his colleagues at Carnegie Mellon's Center for Design of Educational Computing.

But as much fun as these new tools are to use, they're no substitute for a faculty member's presence in the laboratory or the lecture room. "If you are trying to mimic human teachers, you're going to fail," says Sherwood. "A computer doesn't see a student's facial expressions. It doesn't see who's looking out the window, or that this student is interested in ceramics." Not yet, anyway.

–Ann Gibbons





PHOTOS BY KEN ANDREYO

Seeing is believing. Students play Ruth Chabay's "Electric Field Hockey" *(bottom)* to learn how force fields vary with distance; Chabay and Bruce Sherwood *(top)* look at "EM Field."