Computer Networks Bring 'Real Science' to the Schools

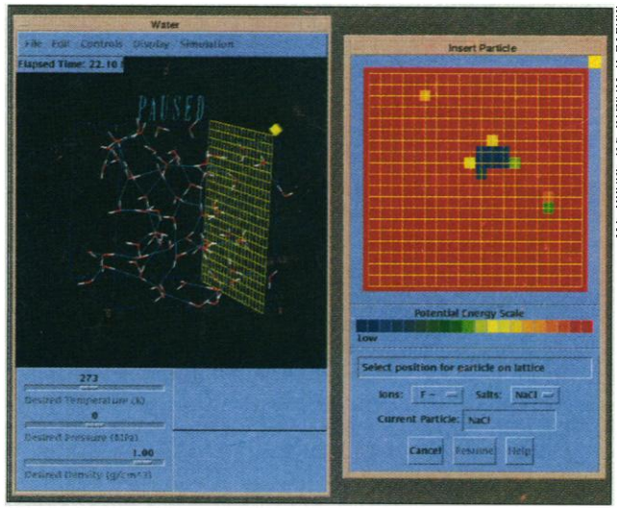
Last year, says science teacher Curtis Craig, 12 students out of 1800 in the student body of American Fork High School in Utah signed up for his first-year physics class. But 180 of them signed up for the classes starting this fall. "It just exploded," says Craig. What made the difference? Hands on Universe, a program piped to Utah from the Lawrence Berkeley Laboratory over a computer network. Hands on Universe hooks Craig's students up with a remote link to Berkeley telescopes, allowing the students to do astronomy just as the scientists do it.

In scattered classrooms around the country, computer networks like this one, as well as e-mail exchanges and satellite hookups, are giving science education a whole new look as educational programs plug students into the world of working scientists. Some students are now getting a chance to talk with oceanographers on location on a research ship, others are getting images hot off telescopes or satellites, and still others are doing chemistry simulations on a computer screen with advice from university professors.

For students, it's made science into a new ballgame. "It's a whole lot more fun to see a water molecule dissolve before your eyes in 10 colors than to read about it in a textbook your teacher used as a student," says Michael Stanley, a Boston high school student whose chemistry class is testing interactive computer simulations that a team at Boston University wants to pipe out to high schools around the world. Stanley's teacher, Chuck Hurwitz, says access to technology that brings cutting-edge science to life is great for teachers too: "There are areas I can talk about with kids now that I never would have been able to in the past." And scientists are excited as well. "One of the most fabulous experiences in my life," is how astrophyicist Carl Pennypacker of Berkeley describes his involvement in Berkeley's telescope access program.

But these programs, unfortunately, are not for everyone. Although the National Science Foundation (NSF) is putting about $20 million into educational technology this year, that's hardly enough to provide teacher training, purchase equipment, and buy time on computer networks for more than a small portion of the nation's schools. And local school administrators, leery of the new technology and strapped for cash, have been reluctant to kick in additional resources.

Following the lead of scientists. Many of the projects that do get going do so at the grassroots level, championed by a persistent teacher or interested scientists. The model for these uses seems to come from scientists themselves. "Over the past 5 to 10 years, networks have been pretty much revolutionizing the way scientists do science," says education consultant John Clement, who works for the NSF's Education and Human Resources Directorate. Networks have made long-distance collaboration, data exchange, and remote control of instruments routine for researchers. Now, Clement says, "the opportunity is beginning to grow to do that in K-12 education." A sampling of these efforts was featured 2 months ago at a National Academy of Sciences symposium, "Reinventing the Schools: The Technology Is Now." But things are moving too fast for anyone, including the academy, to have a complete catalog of developments. "I work at this full time, and I can't keep up," Clement observes.



M.F. GYURE, H.F. STIHLKA, K. BACKKI

Water simulation. Boston University physicists want to network this program out to schools, where students can move the grid through water to places where a salt molecule can be inserted.

The programs currently springing up vary in size from efforts involving one class to countrywide enterprises. Karl Kurz, an industrial arts teacher at Machias High School in Maine, is an example of a solo operator who, with a few hundred dollars' worth of his own equipment, has brought his class into the world of global telecommunications and space travel. Kurz says his shop class used to be "a dumping ground for all the keys that didn't fit." But that began to change a couple of years ago when Kurz, a newly licensed packet radio operator, taught his students how to track, contact, and converse with cosmonaut Sergei Krikalev, trapped in orbit after the collapse of the Soviet government.

Thanks to a friend who manages computer operations at the University of Maine, Kurz got access to the Internet, the global network linking educational and research institutions, and used the system to download a public domain satellite tracking program from the university's mainframe computer into his PC. With it, he was able to predict the 8- to 10-minute weekly window when Mir was in radio range. Then he used packet radio—a type of ham radio that communicates with computers via radio waves—to contact Mir, which also has a packet set, and the class was able to keep in touch with the astronaut for 6 months until he came down in May 1992. "There are very few things kids get excited about these days. Space is one," says Kurz. So he's built on that by getting the class to obtain the latest data on shuttle missions from NASA's Spacelink program, an informational database available over telephone lines, and then tuning in to chew the fat with shuttle scientists as they pass overhead.

On a much larger scale, satellites and computers have made it possible for students across the country to go on remote excursions with the submersible *Jason*. The project was started 5 years ago by Robert Ballard of the Woods Hole Oceanographic Institution. Ballard had used *Jason* to find the *Titanic* in 1985 and also found that his discovery stirred up a tremendous amount of interest among schoolchildren. He then raised corporate, foundation, and government funds to set up a program that involves not only taking 20 9th-graders on annual trips with *Jason*, but arranging for interactive sessions by means of computers and satellites between students at home and the team of explorers. After spending 4 to 6 weeks in specially designed studies, students in the 4th to 10th grades each year go to 28 downlink sites around the country where they get an hour of real-time video images from the sub. This year 300,000 students were involved in five 1-hour sessions. A few of them got to control *Jason*'s movements remotely as the sub poked around the ocean floor. Last year the sub toured hydrothermal vents and watched grey whales off Baja California; next March *Jason* will give the students a fish-eye view of a reef in Central America.

Remote educational explorations are not limited to the oceans. Berkeley's Hands on Universe, launched just 2 years ago, gives

students a continuous pipeline to astronomy. Directed by supernova seeker Pennypacker, the project got started when groups of science teachers, who were in Berkeley using university telescopes as part of a summer research program, began wondering about ways to bring the excitement they experienced about using the equipment home to their students. The answer was remote control through a computer network. Berkeley, with its far-flung telescopes, had already "perfected methods of doing astronomical research in remote locations," says project manager Elizabeth Arsem. The lab obtained a 3-year, $1.2 million grant from NSF which covers curriculum development, computer programming, teacher training, and hardware for the 40 participating schools. Students are now getting real-time images from two telescopes transmitted directly, via modems, to their school PCs. The students can even order the telescopes to take the particular pictures they want.

Craig of American Fork is one of the original teachers involved in the program. He says that it has helped turn his first-year physics class from basically a vocational program in which "no one was interested" into a more "basic, academically oriented" class that has perked up a lot of students' interest in science—especially the interest of girls.

In fact, the whole program is expanding. "We have 150 teachers on the waiting list," says Arsem, who points out that Hands on Universe has "confronted the problem of getting things into classrooms where teachers only have $200 a year in their science budgets" and it has succeeded. Scientists are already available online to give the students advice, but Pennypacker says he looks forward to the day when "we can bring in some astronomers as partners" for truly collaborative research projects with students. Also in the works is a planned "National Student Observatory," where schools all over the country can log in for observation time. Utah's Brigham Young University is interested in housing it, Berkeley will build it, and Arsem says they're hoping to get some hardware donations from industry.

Some schools are plugging into computer networks to study a more down-to-earth topic: the environment. TERC, an educational research and development center in Cambridge, Massachusetts, has been working on a course called Global Laboratory, with funding from NSF. The laboratory is an electronically linked "learning community" of 8th-graders who take part in an environmental monitoring program. Teachers from different schools agree to study a particular topic, such as the low-altitude ozone that produces smog, and then student teams perform experiments with inexpensive adaptations of industry tools, such as ozone monitors, and publicize the results on the network, which this year comprises 100 schools.

In one school, results from the laboratory hit close to home. In San Antonio, Texas, students studying air quality in their classroom discovered that the carbon dioxide level was 2000 parts per million (not dangerous, but 10 times the outdoor level). This indicated something was amiss in the school's ventilating system, according to industrial hygiene chemist Ken Muzal of Liberty Mutual Insurance in Massachusetts, one of the scientists that TERC has lined up to advise the budding researchers. Teachers had, in fact, been complaining for years about the air quality in the classroom, but school authorities had done nothing to investigate. Faced with the students' data, the school brought in a professional whose measurements confirmed the class's readings. And, at long last, the ventilation system was fixed. "For some teachers and some students," says Beverly Hunter of TERC, "this [educational] technology is literally changing their lives."

TOM GIPSTEIN/NATIONAL GEOGRAPHIC SOCIETY

Under the sea via satellite. Student operating remote controls at one of the downlink sites for Robert Ballard's *Jason* Project.

Limited access. The key word, however, is "some." Educational technology still has quite a ways to go before it can lay claim to widescale changes in American education. For the most part, networking in schools "is still a pioneering activity without institutional support," says Clement, who estimates that of the nation's 2 million teachers, "maybe 50,000 have access [to Internet] and 100,000 have heard of it." And even those who have heard of the network then face the challenge of convincing their bosses—school administrators—to let them use it. Schoolteacher Craig complains that "we can't seem to get school districts to buy into it. PCs are relatively easy to acquire but principals tend not to want to even give up a phone line to a teacher." Oak Ridge National Laboratory began to do something about this last year when it started the Oak Ridge Educational Network. The lab trains teachers and has given free Internet accounts to 40 schools in 22 states. Participants get free software that enables students to access Oak Ridge's computer and engage in activities ranging from obtaining data from NASA on the Magellan probe to holding a live discussion with a class in South Africa. And Congress is currently looking at a number of bills to address the funding situation. One is a measure, first introduced in the last Congress by then-Senator Al Gore, that would allocate $120 million over 5 years to help schools access Internet.

Money isn't the only issue, however. Educators would like to see scientists get involved even more directly in these programs. Right now the degree of participation is as variable as the projects themselves. Few researchers get as involved as physicist Eugene Stanley of Boston University's Center for Polymer Physics. After observing that "modern science is simply not taught in [high school] physics," Stanley "decided to require my research group to spend 20 hours a week developing [computer] modules that could be used"—by being plucked off the Internet—"in any high school in the world." The team is creating fancy interactive chemistry graphics that are piped out to a special high-speed PC at Newton South High School.

Stanley admits, however, that when you get in as deep as he is, "it's definitely a major hassle," because the project is a major draw on his time. But as he points out, levels of participation can range from what "nuts like me" are doing, to just answering the odd e-mail query. Argonne National Laboratory in Chicago has, in fact, started a service called "Ask a Scientist," which enables anyone with a PC and a modem to post questions on a bulletin board called Newton. The queries are then addressed by passing scientists. "There should be ways of arranging more scientist participation for those who want to serve—just as there should be ways to serve your country that don't require joining the Army," Stanley says.

Clements of NSF says that the structure of the school day poses additional barriers. "Fifty-minute class periods really militate against doing much with this technology," he notes, since students will have to pick up and gallop to the next class just as they are settling in to some project. Clearly, carving new courses from the universe of knowledge that can now be evoked by a few keystrokes is not going to happen overnight. "The process of working the stuff into the curriculum," Clement says, "is going to take a very long time."

–Constance Holden