High Schools Try New 'Active' Approach to Physics

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NINTH-GRADERS in John Roeder's Active Physics class at the Calhoun School in New York City present a physics demonstration to second-graders.

It's a humid 95° outside, the kind of day when staying alert presents a fair challenge. But in room CL105 of Catasauqua High School, Jim Schaffer's ninth-graders are too busy to notice the heat. Today's lesson is automobile airbags, and the students inflate white plastic garbage bags and then take turns dropping a croquet ball on them. The simple experiment is accompanied by running commentary from all sides. "It's gonna pop—the ball's too big." "Why don't you try letting out some air?" "It's gonna hit the bottom too fast!" "OK, inflate it some more."

Schaffer's 12 students in Catasauqua, Pennsylvania, are among 2500 nationwide who are trying out a new high school physics course that uses hands-on activities to illustrate the physical concepts behind real-life phenomena—sports, transportation, the home. Called Active Physics, it's intended primarily for students who otherwise wouldn't take physics. Indeed, Schaffer's section includes several special education students and a couple of "repeaters."

"These are things you use every day, and you really don't think about them," offers 14-year-old Becki Kase. "But here we figure out how they work."

Starting from scratch

According to data from the American Institute of Physics, only about a quarter of all high school students take physics. Concerns about how to appeal to the other three-quarters motivated the creators of Active Physics, led by Bernard Khoury, executive officer of the American Association of Physics Teachers, Donald Kirwan, former education manager of the American Institute of Physics and now a physics professor at Louisiana State University, and Brian Schwartz, a physics professor at Brooklyn College and formerly the education officer of the American Physical Society. They realized that the vast majority of students perceive physics as irrelevant, too hard and, well, not that interesting.

Putting the course together "has been a massive effort," says Arthur Eisenkraft, the editor and project manager. "We started from scratch." For the past five years, he has overseen the efforts of more than a hundred physics educators and researchers who have helped write, review, test and evaluate the course materials; in person-hours alone, the project rivals some particle physics collaborations. In addition to support from AIP, AAPT and APS, Active Physics received a National Science Foundation grant in 1991.

Last summer, 55 teachers who planned to field test the course practiced activities and model lessons during a one-week workshop at Whitworth College in Spokane, Washington. This summer, field test evaluators at Lesley College in Cambridge, Massachusetts, are sifting through hundreds of reports, questionnaires and other results gathered during the school year. Next year will be spent modifying the course materials and locating a publisher.

In most respects, Active Physics is not your typical physics course. There are six thematic units—medicine, home, transportation, sports, predictions and communications. The highest math used is algebra. The hands-on activities are guided by real-life scenarios. In the home unit, for example, students are asked to imagine that they are part of an international group designing a "universal dwelling" suitable for any environment.

Quizzes and tests are out, replaced by "performance-based assessments." In one such assessment, students pretend to be teenagers who must convince their parents, played by other classmates, to let them drive the family car. Their arguments incorporate what they've just learned about the relationship between speed and stopping distances, how response time affects driving and so on. Patrick Callahan, who teaches two sections of Active Physics at Catasauqua High School, even lets his students vote on how much each part counts in their overall score. "That's always a lively discussion—they construct very logical arguments about why a certain item should get weighted a certain way."

There is very little lecturing, apart from occasional explanatory comments from the teacher. Students spend most of their time working in small groups. "If you have trouble, talk to each other," Callahan instructs the class. "If you still can't figure it out, come to me."

John Roeder has been using the course for two years now with his ninth graders at the Calhoun School, a small private school in New York City. "I don't call it hands-on physics. It's more like body-on.... Students aren't required to sit still in their chairs." In one section, a few kids take full advantage of the opportunity, roaming around the room, yelling to classmates. Next year, Roeder plans to include some discussion on "what it means to be an effective group member." His two sections have 12 and 8 students each, but he wonders if a class larger than, say, 20 would be too unruly.

Active Physics "requires a new teacher, someone who's not set in his or her ways, or else an experienced teacher who can adapt," Roeder says. Beyond that, one needs equipment, some of it pricey. In Schaffer's class on airbags, groups use a camcorder to videotape the experiment and then watch their efforts played back on a TV. (The textbook does offer instructions for using a timer tape in place of the camcorder.) Later in the week, they'll use spreadsheets and graphical analysis programs to study the data.

Course evaluations

Although so far he has only anecdotal evidence, Roeder believes strongly that his students are learning better. At Catasauqua, Callahan and Schaffer are so pleased that they plan to use the course for the entire ninth-grade class next year.

Not that every student in Active Physics is learning all the time. During Callahan's eleventh-grade section, a student abruptly stops working and saunters back to her lab stool, obviously bored. "She's basically waiting for her parents to sign the papers so she can drop out of school," the teacher explains afterwards. "But during the home design unit, she was the class leader."

Ninth-grader Jared Stahler wonders how he'll do in the regular chemistry course next year; he thinks he does better in Active Physics. The chapter on vision has been so interesting, he says, "my mom says I should study optics."

Jenny Caverly, a Catasauqua senior, signed up for Active Physics because it sounded like fun. And it has been, she says. The chapter on driving has been very informative, she adds, although her parents still won't let her get a license. Last semester she took a self-paced environmental science course. "They'd hand us this big pile of assignments and tell us to do it by such-and-such date. It was busy work, you know? I didn't learn anything." Active Physics has been completely different from her other science classes, Caverly says. "I don't really think of it as science."

JEAN KUMAGAI

A WATER PURIFICATION UNIT, open for maintenance, surrounded by villagers in Bhupalpur, India. Water is pumped into the blue plastic holding tank and then is disinfected by flowing past the UV lamp in the unit. No women appear in the photo because, although they typically attend to the community's water needs, "it would be culturally inappropriate for them to pose for a male stranger [the photographer]," Ashok Gadgil explains. (Photo courtesy of Urminus Industries.)

LBNL Creates Water Purifier for Developing Countries

Lawrence Berkeley National Laboratory has traditionally been known for its large-scale research projects, especially in particle physics. But recent shifts in funding have spurred it to diversify and to put increasing emphasis on smaller projects with a near-term payoff. One small team of physicists at the lab has developed a water purification system, based on the use of ultraviolet radiation, that is designed to tackle widespread contamination in rural areas of developing countries. In those areas, often-deadly waterborne diseases such as cholera, typhoid fever, dysentery and infectious hepatitis pose a serious health threat. "Our system," says project leader Ashok Gadgil, "is safe, inexpensive, durable and portable, and it can be assembled and maintained locally."

The approach itself is not new; indeed, UV radiation is used widely for water disinfection in Europe, and is beginning to catch on in the US (where about 5% of waste water is now UV-treated). Some efforts were also made in New York State in the early 1900s, but were abandoned in part because of the introduction of chlorine for water purification. Chlorine kills pathogens more effectively than UV radiation, but consistent application can be a problem. Also, many people do not like the taste, and chlorine reacts with naturally occurring organic compounds to produce carcinogenic by-products.

UV radiation inactivates the DNA in bacteria, viruses and molds, with the germicidal effect peaking broadly at 260 nm. The LBNL treatment system therefore uses a low-pressure mercury arc lamp, which has strong narrow-band emission at 254 nm.

The LBNL design is the first in which the lamp is not immersed in the water during disinfection—a significant improvement because there is no light blockage caused by a build up of mineral deposits and algae on the lamp. Water is disinfected as it flows in a shallow pan a few centimeters below the lamp; exposure to UV light for 12 seconds disables 99.999% of *Escherichia coli*, the bacterium used as a representative marker.

The water flow is gravity driven, making the design very energy efficient. The only power required is 40 W for operating the lamp; the unit can be run even from a car battery, as was the case in initial field tests carried out in 1993–94 in the state of Uttar Pradesh in northern India (see the photograph). It can be installed, for example, between a holding tank and pipelines that feed a communal faucet, or it can be hooked up directly to a pump.

The unit, which has been modified in response to the field tests, now measures 69 cm by 34 cm by 25 cm and weighs approximately 7 kg. (Because there is a patent pending, LBNL's patent department has withheld critical details about the unit's internal dimensions.) And the lamp is now securely enclosed to prevent accidental exposure to harmful UV radiation.

The unit treats up to 15 liters of water per minute, and could serve a community of a thousand people for about $70 per year. All components are mass-manufactured. The unit needs to be cleaned about every six months, the lamp replaced once a year and the lamp ballast replaced every two years.

Gadgil and his team have not carried out further field tests on the modified design because their funding ran out last fall. But negotiations for licensing the technology to EEG Inc are in their final stages. Elwyn Ewald, director and co-owner of the small Chicago business, says that countries in Asia, Africa and South America have indicated interest. Although Ewald believes there is enormous need and market potential, he says "it will be a big challenge to get this to work," anticipating the hurdles of arranging reliable power supplies and getting communities to use and maintain the unit properly. Gadgil is pleased that his team's efforts may make an impact. He also points out that "to effectively combat disease, disinfecting water is a necessary first step, but education in public health and hygiene is essential."

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