SCIENCE EDUCATION

Scientists Return to the Elementary-School Classroom

Jeffrey Esko intended to give the principal at his children's school an earful 3 years ago, but he got his own ear filled instead. "I went to the principal at my kids' school to complain about the science curriculum there," says Esko, a professor of biochemistry at the University of Alabama at Birmingham, "and she told me that if I was unhappy, I should do something about it." He took her at her word.

Esko's daughter had complained that science class was boring, so he set out to develop a curriculum that was as interesting and fun as it was informative. Working closely with fourth-grade teacher Celina Costa at the EPIC Elementary School in Birmingham, he developed a year-long microbiology course in which children collected microbes of myriad shapes and sizes from all over the school. The kids then designed their own classification system for the various bugs. "We wanted them to learn by doing science instead of just reading about it," Esko says.

Esko is one of a growing legion of scientists around the United States who have decided to stop bellyaching about science education and start helping in their local schools, using hands-on teaching aids such as fast-growing plants and insects to illustrate scientific principles. These close encounters with research appear to be working, although the measures of success tend to be qualitative because many elementary schools don't test for science aptitude. The Pasadena Public School system, for example, found that pupils in its Science for Early Educational Development program—implemented with the help of parents James Bower and Jerry Pines, both faculty members at the nearby California Institute of Technology—performed better in all subjects, particularly reading, than they did before the program was adopted.

Yet these efforts are not without controversy. Some educators are concerned that initiatives like Esko's will lead to a piecemeal science curriculum, with no standard knowledge base for children. "We need to make sure that all these new science curricula meet some benchmark criteria and aren't just fun ways of doing science that don't teach," says Fred Finley, associate professor of science education at the University of Minnesota. National groups have spent countless hours and millions of dollars developing innovative science curricula, Finley notes, and he says researchers may be more effective if they help schools implement these curricula rather than devise their own.

In addition, scientists themselves worry that their efforts may be harming their careers. Indeed, they say their universities often look askance at the hours spent out of the lab, and thus helping out an elementary school doesn't pay off at tenure time.

Linking learning and doing. The children in Birmingham certainly seem to appreciate Esko's work, even if his university doesn't. This year, equipped with sterile swabs and petri dishes prepared in Esko's laboratory, they swarmed through the school, leaving no floor, no corner, no surface—including the principal's desk—unsampled. They made detailed observations under a microscope of the blobs and fuzzies that grew in the dishes—bacteria and fungi—and recorded their findings as drawings, prose, and even poetry. Then the students worked as a group to develop their own classification system. Color, shape, texture, movement, and even smell were the key characteristics. It wasn't the world according to Linnaeus, but that wasn't the object of the exercise. The idea was to teach critical thinking and reasoning skills essential to the scientific process. "We didn't want to cram facts down the kids' throats because that's what was boring them in the first place," says Esko. "Instead, we wanted them to learn by conducting experiments, asking questions, observing, hypothesizing, even making mistakes."

JOSEPH ALPER

The art of observation. Fourth-graders in a Birmingham, Alabama, class drew microbes they saw through a microscope.

The connections between learning and doing aren't lost on the children. "That's what I like about this class. We get to learn real stuff and the experiments are fun," says Matthew, one of Costa's students. "It's much more interesting than just sitting and hearing the teacher talk," adds Gino, a classmate. "And we're really learning," shouted out several of the students.

Esko and Costa developed the curriculum together over the course of a summer spent working in Esko's laboratory. With Costa's guidance about the student's abilities and interests, Esko developed the experiments to serve as the heart of the course, with Costa working alongside him to become familiar with both the techniques and the science itself. The major cost of the program was $3000 for a new microscope, money donated by the University of Alabama. And this budget is typical for such initiatives. "Good hands-on science costs less to implement and run than the lousy textbooks that the vast majority of elementary schools feel compelled to use," says Caltech's Bower.

These hands-on programs have many forms. Food, rather than bugs, is illuminating chemistry and biology for third-graders in the Durango Public Schools in Colorado. Ron Estler, professor of physical science at Durango's Fort Lewis College, heard the cries of boredom coming from his third-grade daughter, and so designed a food-based curriculum to teach basic concepts such as pH, concentration, enzymatic action, and energy metabolism.

In Tuscon, Arizona, the Marvelous Munching Melanopus Project has taken hold in the public schools. Developed at the University of Arizona, the Melanopus project has children observing the eating behavior of a common Arizona grasshopper to learn basic biology, as well as using the students' observations to sharpen math and writing skills. Gail Paulin, a teacher in the Tuscon Unified School District, and Elizabeth Bernays, an entomologist at the university, collaborated on the unit's design.

Educating scientists. The kids aren't the only ones learning in these situations: Researchers are discovering how to teach. "Working with elementary-school teachers is an educational experience for scientists, too, because it's the first time they've ever been around someone trained to teach, someone who actually knows what they're doing in the classroom," says Bower, "I recommend this to anyone at a university who cares about the quality of their teaching. I know for a fact that my experience in this program has fundamentally and radically changed the way I teach." For one, he no longer walks into a class and expounds for fifty minutes, preferring instead to "use

what's good practice in the third grade, namely directed inquiry." For example, in a recent class on primate eye movements, he asked his class to tell him what human eye movements are possible. For the next 10 minutes, his students worked with one another to determine the answers themselves.

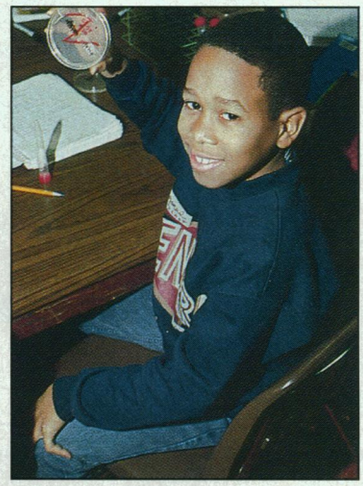
A number of educators say that partnerships among Bower, Esko, Costa, and others like them are extremely valuable. "If we're going to make science accessible to all Americans, starting with our children, then what we expose them to in the classroom has to engage them—just as it does scientists," says Andrew Ahlgren, associate director of the Project 2061 initiative to improve science literacy, sponsored by the American Association for the Advancement of Science (the publisher of *Science*). Julie Graf, who coordinates a Howard Hughes Medical Institute (HHMI)–funded project to develop these programs at the University of Colorado in Boulder, adds: "It's also important that the scientists are there to support the teachers, to demystify science for them."

But not everyone is a booster of what is happening in Birmingham, Durango, and other isolated classrooms in which scientists and teachers are creating new curricula. "I couldn't be more excited about scientists helping our elementary-school teachers and exposing them to real science, but I'm far less enthusiastic about them doing curriculum development," says Minnesota's Finley. "The National Science Foundation [NSF] and others have spent many millions of dollars developing and testing effective, engaging, hands-on science curricula, based on solid pedagogy, for all grade levels, and so it's a waste of an individual scientist or teacher's time to create their own curricula, which may or may not be any good." Even Ahlgren, who's generally supportive of these efforts, is concerned by this aspect. "We need to leave curriculum development to the experts, the people who know the pedagogy to create useful, effective educational tools. This is something that few scientists know about," he says.

Going too far? Bower agrees wholeheartedly. "Whenever I talk to other universities about getting involved in outreach efforts, I stress how important it is to not do curriculum development. It's not what we know how to do, and besides, NSF and others have already developed good curricula. Our role is to help schools adopt them."

That's all very well and good if scientists and school districts know that such curricula exist. Unfortunately, even though NSF publishes and distributes their curriculum through the National Science Resource Center,* that's not always the case. "I knew that I wasn't the only person in the world doing this kind of thing," says Esko, "but I had no idea that there were whole programs available for the asking."

He's not alone. "The sad thing is that even though the U.S. has pioneered the development of hands-on science teaching that we know works, these methods have not spread," says National Academy of Sciences president Bruce Alberts, who has spent the past 5 years helping elementary schools in San Francisco adopt a totally hands-on science curriculum. "As a result, probably less than 1% of our elementary-school students are today being exposed to the type of science education that they need for their future." At NSF, Susan Snyder of the Education and Human Resources Director-



JOSEPH ALPER

Culturing science. Biochemist Jeffrey Esko worked with a science teacher to put microbiology in the hands of Birmingham, Alabama, schoolchildren.

ate agrees. "We've done a pretty poor job of letting people know that there are well-developed, effective, exciting science curricula available," she says.

Another problem lies within the scientific community itself: When push comes to shove, most universities would rather have their faculty in the laboratory than in the elementary-school classroom. "When I was up for tenure a few years ago, I was told explicitly that my work with the Pasadena schools would not be held against me, but it wouldn't help either," said Bower. The implication, he felt, was that the tenure committee saw him frittering away time on elementary-school education instead of concentrating on the traditional scientific duties of research, publishing, and teaching graduate students. In spite of this attitude, Bower did get tenure, based solely on his scientific output.

Caltech might be excused—it is a private school, after all—but this attitude seems to rule in state-supported universities, too. At Oklahoma State University, microbiologist Alan Harker, whose efforts to develop science programs in the Oklahoma public schools are funded to the tune of $2 million from HHMI and $180,000 from NSF, was recently denied a merit raise that would have at least partially compensated him for the time he spends on outreach efforts above and beyond his normal teaching and research load. "My department head and dean are behind me, but the university just doesn't see the value of these efforts."

Penalized for helping. Harker and others who go into the elementary schools feel they are pulling double duty. Esko, who says he spends a minimum of 5 hours a week with the Birmingham children, struggles to find those hours amidst the research and teaching commitments and committee assignments he has at the university. It would be easier, he says, if the university viewed the school work as part of his professional responsibilities, but it doesn't. Says Esko, "Money is not a problem. Finding time to work with the kids is the problem."

A major exception to this pattern is the University of Arizona, which recently became the first university to include outreach as one of the major criteria for tenure and promotion. "Arizona is really the model for all other universities to follow, and they deserve a ton of credit for being a leader in science outreach," says Bower.

Arizona's administration, apparently, viewed the matter more in terms of giving credit to the scientists. Sam Ward, chair of Arizona's department of molecular and cellular biology and one of the forces behind the university's decision to adopt this policy, says "The leadership of this university, from the president to the deans to the department heads, actively supports science education. They've committed money, they've committed staff, and now they've said, quite clearly, that this is an activity that deserves the faculty's time and therefore will be rewarded." The hope is that such rewards will extend, like the scientists themselves, into the elementary schools.

–Joseph Alper

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