Planting SEEDs

"We've tended to turn kids off to science in about the third grade. But if science is made exciting, kids want to know more about it. They want to learn."

by Winifred J. Veronda

Ten-year-old Ralph is trying to think of a new name for his crayfish. Ralph has discovered that the animal, originally christened David, is actually a girl. "Susan" has a pleasant sound, Ralph thinks, but he listens intently as his classmates offer suggestions.

Excited chatter fills the fifth-grade classroom at Cleveland Elementary School in Pasadena, where students are enthusiastically examining their crayfish and observing their behavior. A science lesson is under way, and at Cleveland School that means hands-on science exploration through Project SEED. Leila Gonzales (BS '79), a Project SEED staff member, is a visitor today. A group of children cluster around her as she discusses the varying degrees of aggressiveness in the crayfish the children are holding. One student tells Gonzales that she took her crayfish home, and that it became so gentle she could kiss it.

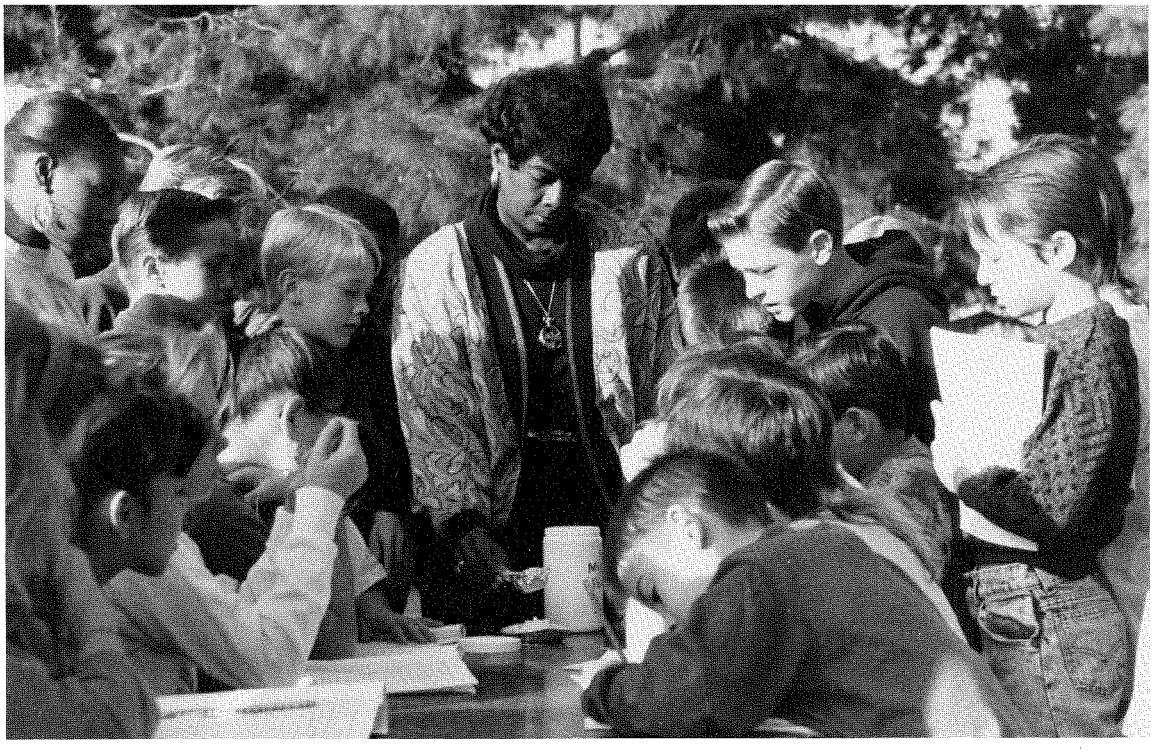
How aggressive is a crayfish? Fifth graders at Field Elementary School learn about animal behavior by observing their own crayfish, as part of Project SEED, a science-education program begun by two Caltech professors.

Project SEED (Science for Early Educational Development) has come a long way since it began as an experimental pilot project in Field Elementary School in 1984—a project focused on teaching students through immersion in the scientific process. Through hands-on inquiry and computer simulations, the kids learn to pose a scientific question, collect data, reach conclusions, develop hypotheses, and invent experiments to test them. Now, thanks to a $645,200 grant from the National Science Foundation, and the unstinting efforts of its creators, Project SEED is expanding over three years to include all 22 elementary schools in the Pasadena Unified School District, (so far it has been established in 20 of them), and additional teachers are being trained each year at every grade level. For kindergarten through fifth grades, it has become the school district's official science curriculum, and this spring the program is being extended to sixth grade in 10 schools. It will eventually reach more than 10,000 children in Pasadena.

For its creators, Jim Bower, associate professor of biology, and Jerry Pine, professor of physics, all this is only the beginning. Already they're looking at ways to extend the program through middle school and high school. Meanwhile, through the interest of Micheal Boughton, BS '55, former president of the Alumni Association, Project SEED has become a part of the curriculum of the Lihikai Elementary School on Maui, and requests for information are coming in from districts located all over the country. As of January it also has an official home—a two-story, 1922-vintage, Caltech-owned house on South Hill Avenue. Institute funds have refurbished the downstairs as a first step, and the house is already being used as a training center for teachers and principals.

"Caltech is doing what it has always done—using its resources, imagination, and energy to develop new approaches," says Bower. If the dream of Bower and Pine comes true, then SEED as an approach to early science education will become a model for raising the scientific abilities of students across the United States.

Both Bower, the biologist, and Pine, the physicist, do research on the biophysics of the nervous system, studying neural networks in brains and in cell cultures. They both are involved in Caltech's interdisciplinary program



Left: Dorothy Hall's class at Sierra Madre Elementary School pays close attention to a science experiment.
Below left: Grad student Scott Strobel conducts Pasadena elementary-school teachers on a tour of Caltech laboratories.
Right: As a group of teachers watches by Baxter Hall, Jerry Pine demonstrates shadows and sundials, part of the fifth-grade unit on daytime astronomy.

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in Computation and Neural Systems. But the development of elementary science education programs has become a kind of second career for Bower and Pine, both of whose commitment to educational service goes back a long way. Almost 20 years ago, when he was a high-school student in Rochester, New York, in the late sixties, Bower was involved in education policy and curriculum reform at the high-school level, as well as in teaching emotionally disturbed children. As an undergraduate intern at Antioch College, he taught kindergarten through third grade. Later he worked as an aide at a state institute in Montana for profoundly retarded children. "I believe everybody owes it to the community to contribute to the education of its children," he says with emphasis.

Pine's commitment dates to the early 1960s, when he was a part of the National Science Foundation-sponsored team that developed the first elementary-school hands-on science kits. In Pasadena, he was instrumental in conceiving Caltech's Saturday high-school education program.

The two linked up in the early eighties. "We were disheartened to see kids in kindergarten and first grade who were more excited about science than they would ever be in their lives because of what would happen to them through the educational system," says Bower, as he reminisces about SEED's inception. "We wanted to maintain their creativity and inventiveness. Children have a natural tendency to explore. Our object was to build a sense of order and direction into that process."

Some schools had experimented with "hands-on" science in the sixties, but most abandoned it as "back to basics" became the mode. The Mesa, Arizona, district was one that had stuck with the use of the NSF science kits in elementary-school classrooms, and 14 of these kits were replicated for classrooms at Field Elementary, Project SEED's pilot school.

The science kits don't work on their own; teacher training has been a vital component. Before the pilot program began, the Field School teachers who would be Project SEED participants met at Caltech with faculty members, graduate students, and postdocs for instruction in the use of hands-on kits and computers. Teachers who showed special promise became mentor teachers and, in subsequent years, helped to train their colleagues.

As SEED has grown, so has teacher training. Last summer, 115 elementary-school teachers participated in a five-day workshop at Caltech. By the end of 1993, Bower estimates, 420 Pasadena teachers in grades kindergarten through fifth will have been trained in the use of Project SEED materials. All sixth-grade teachers at the 22 elementary schools will have been trained as well.

Unique to the program has been the role of scientists in the training process. "Scientists have tended to go into outreach programs disguised as priests," says Bower. "They give sermons, but the teachers don't buy in. At Caltech, the scientists have worked side by side with teachers on the curriculum materials, modeling the process involved in scientific reasoning and

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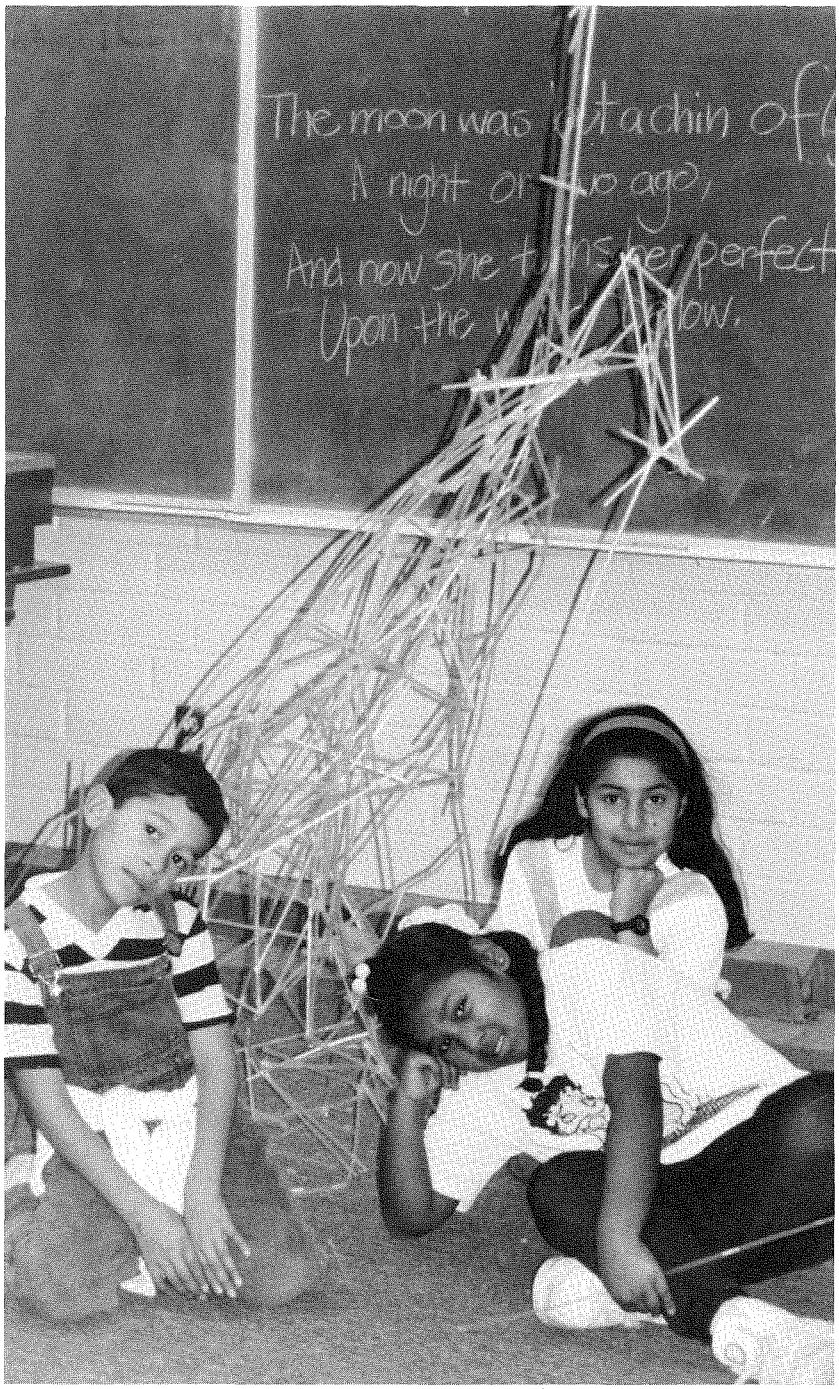
experimentation, and helping them feel more comfortable about their ability to teach science. The scientists let them know it's okay not to know the answers to a question, but to say, 'Why don't we try some things, and see what we can find out?'"

"This may be the only program in the nation where scientists work together with the teachers on the materials the teachers are already using in the classroom," says Jennifer Yuré, Project SEED coordinator for the Pasadena Unified School District.

As the project has grown, others from the community have joined the Caltech scientists in the training process—Caltech alumni, local engineers, and members of the American Association of University Women who have scientific backgrounds. "We feel it's important to involve people from the community, not just Caltech scientists," says Yuré. "If we want Project SEED to be a model for other districts, and we only use Caltech resources, then others will say, 'You have a unique situation. It won't work for us.' We want to demonstrate that any community has people who can support good science teaching." But she adds that it's important for these people to have some research background, because they must model a process where the kids have to seek an answer that isn't known.

Project SEED leaders have been pleased with the enthusiastic response of the Caltech scientists to their role in the innovative program. "Several left their phone numbers with the teachers at the end of the summer training, saying, 'Call if you need me,'" says Yuré. "And teachers have asked



The leaning tower of Pasadena? Third graders at Cleveland Elementary School (above) show off their straw structure—the tallest in the class.

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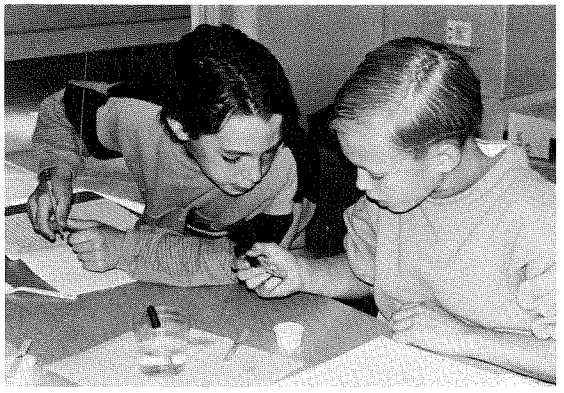
them to come help with a lesson, or talk about what they do. This has been good for the kids, because they get to see that scientists are normal people. It has helped to demystify science."

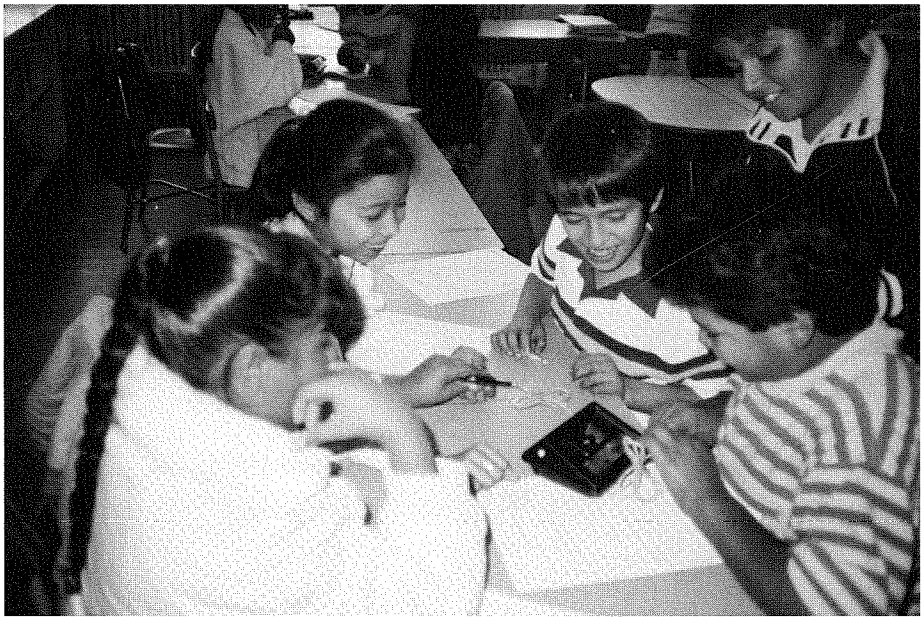
Equally pleasing was the response of principals at an introductory training session on Project SEED methodology. Originally planned for twice a year, the principals decided they wanted to work through some of the science kits themselves, and opted for monthly sessions. Pine and Bower are planning evening training sessions for parents, to show how they can do hands-on science with their children.

Teachers are gratified by the way Project SEED entices many high-risk kids with poor reading and writing skills. Fascinated by the experimental science, they find they can participate in SEED on an equal footing with their peers, offering suggestions and reaching conclusions. "One teacher told me about a kid who spent most of last year in the principal's office," says Yuré. "Now he won't leave her room when science is in progress, and he begs to stay in at recess to continue working with the experiments in the kits."

Pine points out that "SEED is not just about science. It cuts across the lines dividing scientific and mathematical disciplines, and also involves language skills and the social sciences. It helps children develop skills in critical thinking that are needed in every aspect of life."

Teachers who may originally have feared that Project SEED would take over the entire classroom have learned its value for incorporating such subjects as vocabulary and history. History





Fifth graders (above) at Sierra Madre Elementary debate the identity of a "mystery powder," while others (far right) study electricity. Below: A third grader's round, clay "boat" teaches her about water displacement, volume, and weight.

can be integrated into a unit on plants, for example, if a teacher explains how ancient civilizations planted and harvested crops. Reading and writing come into play if students are asked to write poems about their favorite plants, or to read supplemental material from books.

Although it's too early to tell how SEED will affect students' future interest in science, Yuré notes that two members of the original Field School group have gone on to win at the science fair in middle school.

Each of the five grades participating in SEED studies four units of hands-on science during the year. And seeds really do play a role. First graders, for example, grow seeds during the first quarter, learning about the parts of plants. How do you learn what's actually a seed? Well, you plant one and see if it grows. Some red hots, distributed with the kits, have failed to meet the test, despite the hopes of the children who planted them. During the second quarter, first graders study the five senses. Frogs and tadpoles are topics during the third quarter (some frog eggs get planted as students remember their seed project), and the children end the year learning about pollution.

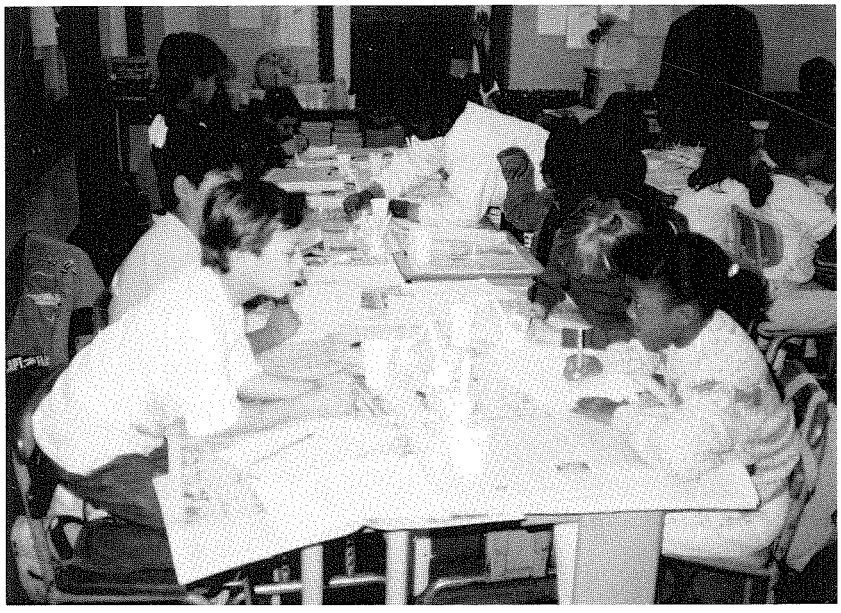
Third graders start with a lump of clay in the first quarter. Making boats from the clay, they learn about water displacement, volume, mass, and weight. After that they study brine shrimp. In the third section, they use straws to support a book and then build more and more complex structures. And during the last quarter they study scientific reasoning, observing pendulums and other mechanical devices that demonstrate engineering principles.

By the time they are fifth graders, they are studying "mystery powders." Students are given five unidentified common white household powders to identify by using their senses and various tests involving heat, iodine, and water. They go on to learn about electricity, using batteries and bulbs, making switches and fuses, and aligning poles. The third and fourth quarters bring in daytime astronomy (building sundials is included here) and the ever-popular crayfish.

Computer simulation has been a part of the Project SEED curriculum since the beginning and continues to be tested in the Field School, where SEED was launched. "We've tried to mimic the way scientists use computers in their research, but at a level appropriate for elementary school," Bower says. Working with him have been Caltech faculty, research staff, and students at Caltech, and computer scientists at TRW, Inc.

At Field School, for example, a simulation model of growing seeds enables students to use a computer to control the number of sunny days that corn will get, the number of cloudy days, and the amount of rain. They can watch the corn grow, decide when to harvest, watch a little harvester come on the screen and cut the corn stalks, and they can then measure the yield. Through a computer kids can even venture inside a cornstalk, discovering how water flows there and how photosynthesis works.

The computer programs reinforce the hands-on science offered through the kits. They allow students to increase complexity, accelerate or slow down time, expand or contract space, and



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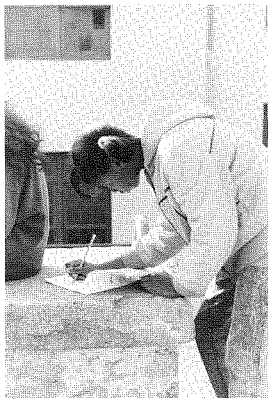
Science can be exciting with a little help from your friends, or intent on a project by yourself.



access additional data. Students can use the computer for graphing and analyzing real data obtained from the simulations. They learn concepts of data retrieval, data recording, and data abstraction.

Bower and Bill Gross (BS '81), president of Knowledge Adventure, a computer simulation firm, are collaborating on making better software for children's science education. (Gross may be remembered by many in the Caltech community for his first company, GNP—Gross National Product—famous for its Valkyrie speakers, which Gross designed.) Bower is also looking into ways to market the simulation programs he and his colleagues have developed, and plans to use any profit for further simulation research. The Apple Computer Vivarium Project supplied the computers for the pilot program. Project SEED is also supported by the Pasadena-based Community Bank, TRW Inc., the Caltech President's Fund, the Educational Foundation of America, and Rockwell International.

A new phase in SEED's expansion gained impetus in 1990 when the Alfred P. Sloan Foundation awarded a three-year $300,000 grant to develop a computerized science library. The library program, developed in collaboration with the UCLA Graduate School of Library and Information Science, uses Apple Macintosh software graphics to give students access to information in public libraries. Information from 57,000 children's science books in the Los Angeles Central Library has been converted for reading on computer.

"SEED is supposed to excite kids about science," Bower remarks. "It seemed unfair to excite them and then leave them without ways to get additional information." In creating this project, Bower and his colleagues are investigating the information-seeking behavior of children and designing software that kids can easily use and understand.

The library program also features a computerized adventure game designed to inspire students to seek out information. The game introduces a rural environment with a farm, a swamp, woods, and a small town. The kids can wander through the environment on the computer screen by manipulating controls. In each section, they meet various animals, for example, a frog in the swamp. Initially the frog dives out of sight into the swamp. But if the child learns to feed the frog a bug, the new friend takes the child with it to the bottom of the swamp where it leads the child on a tour of the frog's world.

The library system has now been introduced to the Ninth and Tenth Street schools in Los Angeles and the University Elementary School at UCLA. It's also in the children's section of the Los Angeles County public library. Through the Ninth and Tenth Street schools, says Bower, "we're gaining piles of information about how homeless kids and kids from other language and cultural backgrounds use the library to get information."

An unexpected side effect of Project SEED has been the enthusiasm it has generated in young Caltech scientists. One of these, Leila Gonzales, after graduating from Caltech with a BS in biology, earned a PhD in developmental genetics

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Right: Jim Bower discusses hands-on science with teachers, and (below) two students from Dean Cooper's class at Field Elementary School give some serious thought to their crayfish.

at Harvard and came back to Caltech as a postdoc. Investigating computational neurobiology in Bower's lab, she volunteered to become involved with Project SEED and now works with it full time. She has decided to change her career from science research to science education.

Says Bower, "One of SEED's contributions may be to set up a pipeline for people who find in Project SEED an opportunity to use their imaginations and their science training in ways more directly related to human beings than if they went into research. As it's turning out, we're not only training kids, we're training scientists to train kids."

In March scientists and engineers who are interested in becoming involved in kindergarten-through-12-grade education came to Caltech from all over the country for a working conference on precollege science education. It was sponsored by the National Science Resources Center, which is operated by the Smithsonian Institution and the National Academy of Sciences. Educators already experienced in developing innovative curricula in science explained their ideas and programs during the week-long conference. Visits to Pasadena elementary schools to see Project SEED in action demonstrated the enthusiasm that children can bring to learning science.

"Doing something is a better way to learn about it than reading or hearing about it," says Pine, pointing out that many Caltech scientists didn't become enthusiastic about the subject in the classroom. They learned in their basements, creating their own experiments. "We've tended to turn kids off to science in about the third grade," says Bower. "But if science is made exciting, kids want to know more about it. They want to learn."

"Our students," says Yuré, "are having a ball." □

Winifred Veronda recently retired as editor of Caltech News *after 20 years at the Institute.*