Launching Science Education Into the 21st Century *By Rhonda Barton*

A 184-pound metal ball named Sputnik changed the course of science education in the United States almost a half-century ago. When the Russians successfully launched the world's first satellite in 1957, it served as a flaming wake-up call—speeding by at 18,000 miles an hour. America was losing the race for space, and if we didn't step up our science and technology efforts, we literally would be left earthbound.

The nation was galvanized, a new emphasis was placed on science, and a mere dozen years later, Americans left their footprints on the moon. However, that single-minded push wasn't sustained and the trajectory of U.S. students' science performance faltered.

The latest Trends in International Mathematics and Science Study (or TIMSS), released in December 2004, shows that U.S. eighth-graders scored better in science in 2003 than in 1999, but still lag behind their peers in a number of other industrial countries. Scores for fourth-graders, who also rank behind their peers, declined over the four-year period. Of the 45 countries participating in the eighth-grade survey, the United States placed ninth; among 25 countries reporting fourth-grade results, the U.S. took sixth place.

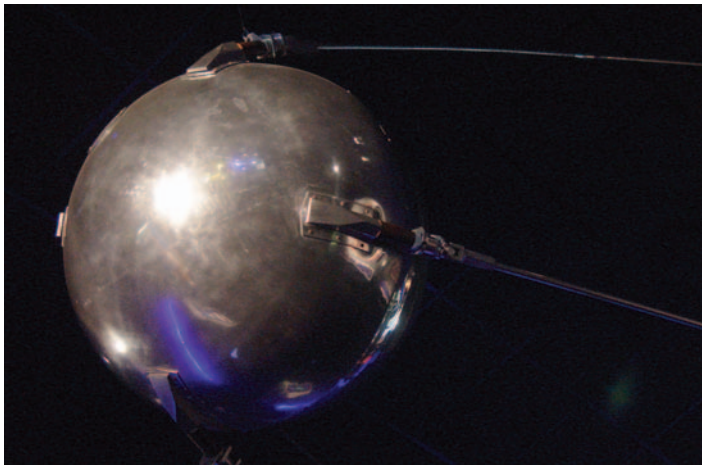
Another international survey, the Program for International Student Assessment (or PISA), targets 15-year-old students and measures how well they apply knowledge to real-life problems. According to PISA, the U.S. ranks about in the middle of the pack in scientific literacy—scoring higher than seven industrialized nations and lower than seven others.

Perhaps a more depressing picture of the state of science achievement is yielded by numbers from the National Assessment of Educational Progress. According to NAEP, 29 percent of fourth-graders scored at or above the proficient level in science assessments in 2000; eighth-grade scores were only slightly better at 32 percent; and 12th-graders had a dismal showing at 18 percent.

Reflecting on such standings, the National Commission on Mathematics and Scientific Teaching for the 21st Century said that students' science preparation was "in a word, unacceptable." In its 2000 report, the commission—chaired by former astronaut and Ohio Senator John Glenn—called for a more rigorous curriculum, focused professional development, and above all, more highly qualified teachers. "[B]etter teaching is the lever for change," said the commission, observing that 56 percent of high school students taking physical science are taught by out-of-field teachers and nearly one in five high school science teachers lack even a minor in their main teaching field.

ON NCLB'S RADAR

The No Child Behind Act, which requires Title I schools to provide instruction by highly qualified staff, will extend to science education during the next school year. All states must develop science standards by 2005–2006 and must administer annual science assessments at least once in three different grade spans (3–5, 6–9, and 10–12) by 2007–2008. Although the stakes aren't as high as for reading and math—science scores won't be linked to adequate yearly progress—the new mandates are adding immediacy to the debate over what constitutes good science education.



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To date, there's no single, research-based answer to that question. As then-Secretary of Education Rod Paige pointed out at the first Secretary's Summit on Science in March 2004, "Much more high-quality research is needed to determine what methods, resources, and curricula are best for educating students at all grade levels." While progress has been made, Paige remarked that "for the most part, we're still blindfolded and trying to find our way through a cluttered room."

The National Research Council (NRC), a branch of the National Academies chartered by Congress, is in the midst of three studies that should shed more light on the subject. One project—targeting kindergarten through eighth-grade students—is culling research from a variety of fields on how science is learned and what are the critical stages in children's development of scientific concepts. A second project aims at providing practical advice on designing tests that tap into

what students really know about science. And the third NRC project focuses on the role of high school science laboratories in promoting teaching and learning.

Some educators have expressed concern that in the rush to meet national standards, schools are cutting back on the total amount of time devoted to studying science and they're replacing laboratory experiments and other forms of inquiry-based instruction with rote memorization. This is despite the fact that inquiry science—which involves activities and skills that focus on the active search for knowledge or understanding—has been endorsed by both the NRC and the American Association for the Advancement of Science. Writing in *Phi Delta Kappan* (April 2002), Olaf Jorgenson and Rick Vanosdall of the Mesa (Arizona) Unified School District state, "Ironically, even as inquiry methods and science resource centers stand poised to reinvigorate K–12 science education in America, the national movement emphasizing reading, writing, and mathematics instruction, as measured by high-stakes standardized tests, threatens to suppress the effort to make truly revolutionary progress in science education."

The authors go on to cite two Wisconsin studies and one in the El Centro (California) School District that linked improvements in science achievement scores to inquiry-based science instruction. In the case of El Centro—a high-poverty district with a high enrollment of minority youngsters—science scores among fourth- and sixth-graders improved the longer they were taught using inquiry methods. Jorgenson and Vanosdall note that the students also showed "impressive improvements" in writing proficiency and SAT-9 mathematics and reading scores.

A more recent study of an inquiry science program for low-income urban youth tracked 8,000 middle grade students in Detroit for three years. As reported in the November 2004 issue of the *Journal of Research in Science Teaching,* the study showed statistically significant increases on curriculum-based tests for each year of participation. Ronald Marx and coauthors report, "The findings indicate that students who historically are low achievers in science can succeed in standards-based, inquiry science when curriculum is carefully developed and aligned with professional development and district policies."

COMPETING APPROACHES

Inquiry methods are eschewed by proponents of "direct instruction" who believe that highly prescribed curricula and classroom procedures are more effective in science education. The National Institute for Direct Instruction, based in Eugene, Oregon, weaves science content into its primary grade reading materials and provides videodiscs for middle and high school science classes. Administrative Director Kurt Engelman expects the coming NCLB science requirements to prompt more queries about the institute's science products.

Direct instruction advocates have been buoyed by recent research by David Klahr, a psychology professor at Carnegie Mellon University. Klahr and his colleague, Milena Nigam, studied more than 100 third- and fourth-graders who were asked to devise experiments with balls and ramps of different sizes and materials. The children were randomly assigned to two different groups. In the direct instruction group, students watched teachers conduct experiments and explain principles before attempting experiments on their own. In the discovery learning group, children designed experiments with only a minimum of teacher intervention. As reported in *Psychological Science* (October 2004), students in the direct instruction group performed better, on average, than those in the discovery group. They were also better able to transfer their knowledge to a new situation at a later date.

While Klahr's results are getting widespread attention, other researchers note that the study exaggerated the teaching methods that were tested: Rarely is totally unguided inquiry or discovery used in the classroom. Even Klahr himself told *Education Week* (November 10, 2004) that while complicated science lessons often call for a more direct approach, teachers should avoid strict adherence to one method or the other. Rather, he said, "It depends on what's being taught." Klahr and Nigam have called for additional research to "generate an empirically sound basis for determining the most effective matches between topic, student, and type of pedagogy."

As the argument over how to teach science goes on—whether it's steeped in inquiry or direct instruction or a combination of both—no one is questioning the critical role that science will play in the 21st century. At the March science summit, Secretary Paige acknowledged that America's response to Sputnik in 1957 paved the way to putting a man on the moon and shaped today's world. "Now," he said, "we must prepare a new generation to choose its destiny. We do so knowing that education is emancipation, and science the source of dreams." ■