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ABSTRACT

This newsletter issue focuses on the issue of recommended instructional and curriculum changes that are part of the current reforms in science education. The issue is composed of four articles. The first article, "Science Education: Schools Pushed To Broaden Access, Overhaul Practice," discusses the call for a science curriculum that prepares scientists and graduates to be functional members of society. The second article, "NSTA Plan Presses Science for all Students, Every Year," discusses the National Science Teacher Association's Scope, Sequence, and Coordination program that seeks to change the present modes of organizing and teaching science content. The third article, "Project 2061: Mapping the Long Path to Science Reform," examines the phases of change, proposed curriculum models, and some results of Project 2061, the reform effort of the American Association for the Advancement of Science. The fourth article, "National Science Standards Will Align Change, Experts Hope," discusses development and implementation of the National Research Council's project to establish science standards in the areas of curriculum, teaching, and assessment. (MDH)

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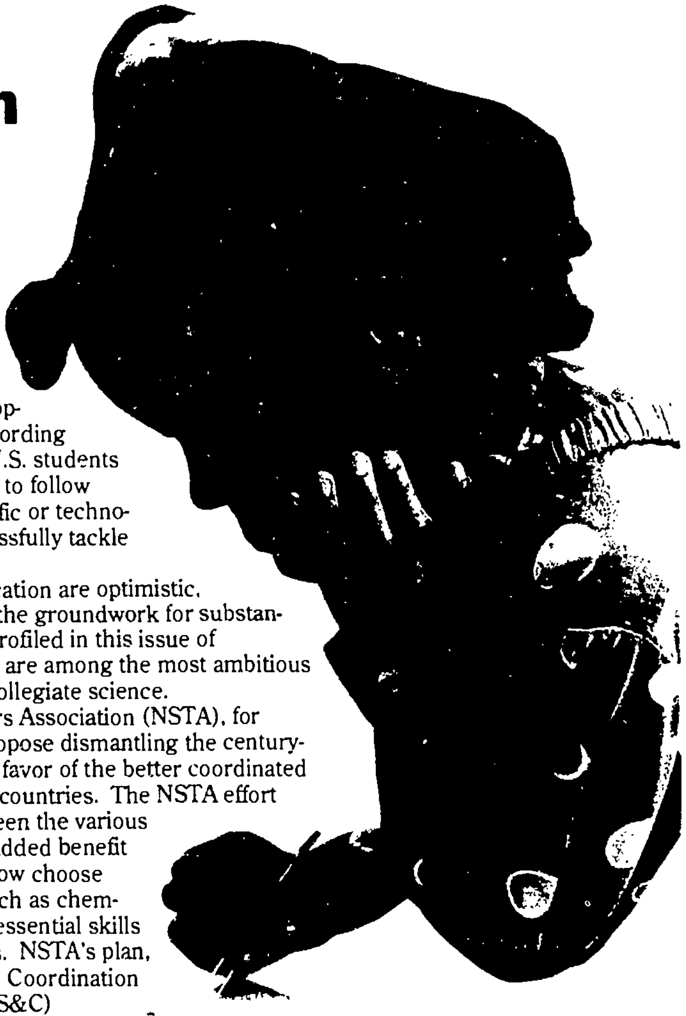
(703) 549-9110

Science Education:

Schools Pushed to Broaden Access, Overhaul Practice

By John O'Neil



When children start school, most have an innate curiosity that seems perfectly suited to learning about the wonders of science. By the time they graduate, though, American students have lost much of their original enthusiasm for the subject. The majority drop science after fulfilling graduation requirements, skipping chemistry and physics altogether. And their performance on national and international assessments of science proficiency ranges from poor to mediocre.

Responding to new demands, science educators are trying to explain this bleak picture—and do something to improve it. With issues such as global warming capturing public attention, and U.S. economic strength depending, to some extent, on scientific and technological advances, experts say the time is ripe for a major overhaul of how science is taught. Unlike previous reform movements in science, however, which tended to focus on preparing future scientists, current efforts are even more ambitious: producing future science professionals *plus* ensuring that all graduates are able to thrive in a society where some science knowledge is necessary merely to be a competent citizen.

"I don't think the scientific and education communities should be in the 'weeding out' business," Bassam Shakhashiri, a chemistry professor at the University of Wisconsin—Madison who formerly worked at the National Science Foundation, says in what has become a recurring complaint about present science programs. "We need to be in the talent development business."

The emphasis on talent development comes none too soon. According to some experts, relatively few U.S. students understand science well enough to follow public issues that involve scientific or technological elements, let alone successfully tackle college-level science courses.

Some experts in science education are optimistic, however, that the field is laying the groundwork for substantive improvement. The efforts profiled in this issue of *Curriculum Update*, experts say, are among the most ambitious ever undertaken to change precollegiate science.

The National Science Teachers Association (NSTA), for example, is going so far as to propose dismantling the century-old "layer-cake" organization in favor of the better coordinated courses more common in other countries. The NSTA effort builds on the natural links between the various sciences, and it could have the added benefit of ensuring that students who now choose not to take year-long courses such as chemistry and physics will still learn essential skills and ideas from those disciplines. NSTA's plan, called the Scope, Sequence, and Coordination of Secondary School Science (SS&C) project, is currently being tested in five states and in Puerto Rico.

Project 2061, launched by the American Association for the Advancement of Science (AAAS), is a massive, long-

Warning Signs

Students

- Students like science less as they get older. Although 80 percent of 4th graders like science, only 65 percent of 12th graders do.
- Only 7 percent of high school seniors are believed to be prepared for college-level science courses.
- While the vast majority of students take biology, only 45 percent take chemistry and 20 percent take physics before graduation.
- Minority students continue to lag behind their peers in science courses taken and in science achievement. The performance of black 12th graders, for example, is close to the national average for all 8th graders.

Teachers

- Only one in three elementary science teachers meets National Science Teachers Association standards; elementary teachers report feeling less well prepared to teach science than reading, math, or social studies.
- Eight percent of biology teachers, 8 percent of chemistry teachers, and 12 percent of physics teachers nationally are not certified to teach their subjects. In some states, these figures rise to as high as 30 percent.

The Public

- Only 7 percent of the American public can be considered scientifically literate. One-half of the public does not know that the earth goes around the sun once a year, and one-half incorrectly believe that the earliest humans lived at the same time as dinosaurs.

Sources: Students: U.S. Department of Education; Council of Chief State School Officers. Teachers: National Science Teachers Association; Council of Chief State School Officers. The Public: Public Opinion Laboratory, Northern Illinois University.

term plan for improving student literacy in mathematics, science, and technology. The first major outcome of the project was a report issued in 1989, *Science for All Americans*, which proposed the knowledge, skills, and attitudes that students should have as a result of their K–12 science experience. Teams of educators are now preparing alternative curriculum models incorporating the material in *Science for All Americans* and a set of "benchmark" statements describing what students should know and be able to do by various grade levels. Within the next few years, these will be supplemented by a computer database of appropriate resources for school districts that attempt to revamp their science curriculums around this new model of scientific literacy.

The most recent initiative, launched late last year, is spearheaded by the National Research Council (NRC) to develop national standards in science. Using a consensus process, working groups convened by the NRC will develop standards for curriculum, teaching, and assessment. Proponents of the effort believe national standards in science, though voluntary, will influence state curriculum and instructional frameworks, assessment practices, teacher preparation—and eventually classroom practice. The standards are expected to be completed by 1994.

A Systemic Focus

Skeptics wonder whether these three projects will contribute to widespread changes in science education that have eluded previous reformers. In the wake of Sputnik, for example, national curriculum projects were launched that yielded high-quality materials but failed to penetrate classrooms widely. Why will this round of reforms be different?

"It's the 'S-word,' " suggests Susan Loucks-Horsley of the National Center for Improving Science Education. "People are thinking more systemically" than they did in previous reform efforts. States, national groups, and the federal government are now seen as more likely to align their improvement efforts in curriculum, assessment, teacher preparation, and staff development. The drive to establish national standards in science, say experts, will contribute to a more systemic approach to improvement.

Moreover, improvement strategies are now driven by some important common ideas: *all* students need some deeper understanding of science; core concepts of science need to be explored at several different grades in successive depth, moving from the concrete to the more abstract; classroom activities should draw on students' prior knowledge and experiences and actively engage pupils in *doing* science; and science lessons should, when appropriate, connect content from other disciplines.

Still, the relatively modest gains of the past decade suggest that considerable challenges lie ahead if science education in the United States is to improve systemwide. "We've made some incremental progress and begun to define the direction we need to move," says Shakhashiri. "But what we have most right now is inertia dominating. We do things, for the most part, the way we've done them before. What we need is fundamental, systemic change in what we do and how we do it." The projects described in this issue of *Curriculum Update* are serving as an experiment of sorts, testing whether science educators can make good on their goal of scientific literacy for all students. ■

NSTA Plan Presses Science for All Students, Every Year

As part of a study of local water sources, students on opposite coasts—D.C. Virgo Middle School in Wilmington, N.C., and West Lake High School in Westlake, Calif.—found themselves on the same team.

Students at both schools met with scientists to gather information about how to investigate local water sources. They made predictions about what their study might turn up. Then each group conducted a chemical analysis of their water samples, investigated the geography of the water sources, measured the current, and explored the energy systems supported by the local water sources. After conducting their research, students from the two schools shared their data and conclusions through an electronic network.

Karen Hill, who helped develop the activity, recalls that one of the North Carolina students pointedly asked a local scientist helping with the project: "You mean you do this for a living?" Somehow, the concepts that too frequently lie dormant in science books had come to life for these pupils. "Students, for the first time, were seeing real-life applications" of the content of their science courses, says Hill, director of technology for the North Carolina Scope, Sequence, and Coordination of Secondary School Science (SS&C) project. North Carolina is one of six sites testing the SS&C program, which was developed and is being run by the 50,000-member National Science Teachers Association (NSTA).

The NSTA would like to open a few more eyes—and minds—with its star project, which is challenging some of the most enduring aspects of the science education status quo. The SS&C program promotes radically changing the organization and delivery of science content—and ensuring that *all* students, not just a self-selected few, experience this new approach to the subject. The program is being tried in several hundred pilot schools in Alaska, California, Iowa, North Carolina, Texas, and Puerto Rico.

Funded with $13 million in grants from the National Science Foundation and the U.S. Department of Education, SS&C is built on the goal of "every science, for every child, every year," says Martin Apple, who serves as national project manager.

Tackling Entrenched Practices

Although the NSTA's vision can be summarized succinctly, achieving it will require tackling some of the most entrenched practices found in American schools.

In traditional American science programs, courses are sequenced in a "layer-cake" configuration of one-year survey courses; the typical order in high school is earth/space science, biology, chemistry, and physics. This layer-cake approach, NSTA and other critics say, ignores obvious connections among the scientific disciplines. And it means that concepts raised in one course might not be revisited for several years, if at all, making it tougher for students to build on prior knowledge. "With this layer-cake curriculum, U.S. students rarely develop an interest in science, not seeing how the sciences interrelate with each other and human concerns," states an NSTA guide to SS&C.

Moreover, American schools typically track students into different ability groups. As a result, even courses with the same title, such as biology, may feature vastly different content for students in low- and high-ability groups. And because so many students opt out of science classes as soon as their graduation requirements are completed, the *majority* of students never take a high school course in chemistry or physics (about 45 percent of students take a chemistry course, and 20 percent take a physics course). Thus, critics question whether scientific literacy is possible for all students if tracked classes continue.

"We're trying to open up options for students, when the traditional design [of the science curriculum] and the practice of tracking foreclose them," says Thomas Sachse, director of the California SS&C project.

A New Approach

As the SS&C name suggests, the project focuses on the issues of scope, sequence, and coordination, seeking to transform the approach to these components, compared with more conventional science programs.

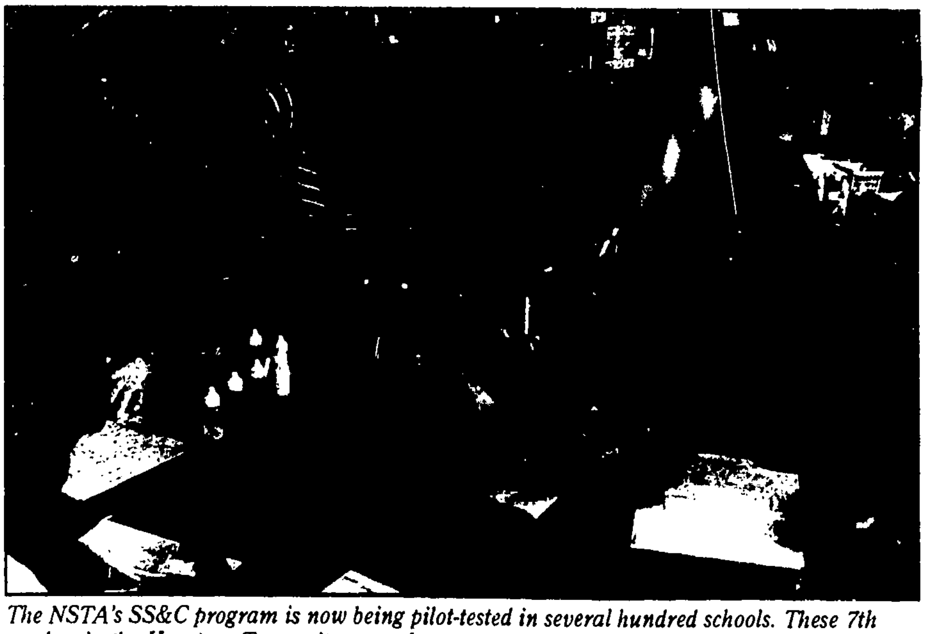
Scope. A fundamental flaw with present science courses, experts charge, is that they tend to stress coverage at the expense of depth. Classes sprint through textbooks containing hundreds or thousands of vocabulary terms or "factoids," rarely allowing sufficient time for experiments or investigations that would help build students' understanding and pique their interest. "It's less important to cover 1,000 topics and not have students understand them than to cover 250 and have students *really* understand them," says the NSTA's Apple. Attempting to scale down on sheer coverage and the dependence on textbooks, many of the SS&C courses being tried at the pilot schools use no textbooks at all or use them only as one of many resources.

Sequence. The SS&C plan also tries to take advantage of research about how children learn best. Instead of confronting students with abstract concepts and terminology first, the SS&C approach begins by engaging students in concrete, hands-on activities. Lessons are meant to show students how science theories play out in the world around them. "We want to show the utility of a concept like density," says Robert Yager of the University of Iowa, which is overseeing the Iowa SS&C pilot. "We keep trying to invent situations where these basic concepts will be needed."

Another strong emphasis of SS&C is teaching concepts in several different contexts over the course of the school year or several years. Students in SS&C classrooms "really have the opportunity to understand some of the major concepts, because they're presented in various contexts," says David Andrews, principal investigator for the North Carolina SS&C project.

Coordination. Perhaps the most radical change the NSTA proposes is its goal of offering every science every year, through coordinating the content of the various disciplines or actually integrating them completely. Depending on the approach taken by local schools, courses might be integrated or organized so that students study different disciplines on different days of the week or in alternating school quarters. (See "How Might Science Be Organized?" on page 4.)

A four-week unit suggested by the NSTA is one example of how content from the science disciplines could be integrated. Students examine a series of questions: What is density? How do I measure the density of a solid or liquid? Why do some things float and others sink? Through a series of activities, pupils study density, marine organisms, oceans, and solutions, thereby integrating concepts from physics, biology, earth science, and chemistry, respectively. Using real materials, such as wooden blocks, they test their hypotheses about density. Then they extend the knowledge by taking on the broader question: How is density useful to humans and



Jim Caldwell

The NSTA's SS&C program is now being pilot-tested in several hundred schools. These 7th graders in the Houston, Texas, site are using tests to identify basic food groups.

marine animals? Through such a coordinated unit, NSTA believes, students would be more likely to see the connections among the science disciplines, as well as more likely to understand the material.

Testing the Theory

Over the past several years, educators at the pilot sites have taken different routes toward achieving the SS&C vision. And though little hard information is available so far on the project's results, the pilot schools are reporting some encouraging preliminary findings.

The North Carolina project, for example, involves seven middle schools from across the state. New SS&C courses for the 6th grade were piloted in 1991–92, and courses for the 7th grade are being implemented this year, according to Andrews.

"What we're trying to do is to teach less, in more depth, and associated with other parts of the curriculum," says Mary Jessup, a 6th-grade teacher at Noble Middle School in Wilmington, N.C., one of the pilot schools. In the past, state-mandated curriculum objectives and tests forced many teachers to closely follow the textbook, says Jessup, a teacher for 33 years. But the state has strongly supported the SS&C goals, she says, making teachers in the pilot schools more comfortable with using hands-on activities. "Before, I don't think the children have ever been allowed to *be* the scientists," Jessup says. "In science, to do it is to remember it." As a result of the reorganized science classes in the pilot schools, 87 percent of students reported liking science, compared to 38 percent before the program was implemented.

"High-risk" students are among those who prefer the SS&C courses over the old ways of teaching science, says Linda Crow, who directs the SS&C pilot project in the Houston, Texas, schools. Students who used to skip science class are now sticking around for the hands-on emphasis. The Houston program, being piloted in the district's middle schools, is organized around a series of "blocks" that draw on all the scientific disciplines. One block used in 8th grade, for example, is called "Fueling Around." In one sample activity ("Pond Bottom"), students learn how organic matter changes over time through an experiment in which pupils pack a mixture of soil, egg shells, hardened egg yolk, sawdust, and pond water into a two-liter plastic bottle. The bottle is placed in indirect light, and students observe what occurs over the next two months (with luck, a multi-colored array of algae and bacteria appears at various locations in the soil at different times). The lab contributes to a discussion of how coal and oil develop.

"These classes are really student-centered," emphasizes Crow, who is an assistant professor at the Baylor College of Medicine. Teachers in the pilot schools say that students are more self-directed as a result of the new approach, she adds.

At Monte Vista High School in suburban San Diego, Calif., one of nearly 200 California schools taking part in the pilot program, teacher Chuck Downing also reports that students in SS&C courses are enthusiastic about the new approach. Fewer than 10 percent of the school's students had been electing to take a third year of science, he says, but 30–35 percent of students in their second year of the SS&C course planned to take a third year of science. One benefit of the new arrangement, Downing believes, is that students "get a much broader exposure to science than they ordinarily would." The study of earthquakes, for example, included in the SS&C course sequence, was not a part of the traditional sequence of separate disciplines, an omission Downing calls "ludicrous," given the locale.

Preliminary data from Iowa, where SS&C is being implemented at five different sites, indicate that the SS&C focus on practical applications of science is paying off, says Yager of the University of Iowa. The Iowa SS&C project emphasizes a Science/Technology/Society approach, a way of teaching science that strongly promotes placing concepts in the context of real-life issues. Results from the project so far show that students are better able to apply what they've learned in new contexts, rather than merely being able to parrot back what

How Might Science Be Organized?

If the "layer-cake" organization to science curriculum is obsolete, as critics charge, how might content from the various sciences be better organized to promote scientific literacy for all students? *The Content Core: A Guide for Curriculum Designers*, issued this year by NSTA after several years of work, suggests some answers.

There are two major routes, and myriad underlying possibilities, to linking subject matter from the various science disciplines—earth/space science, biology, chemistry, and physics—in a coherent series of courses.

One route is through *integrated courses*. These would be single-year courses in which the ties between the disciplines would be relatively seamless. *The Content Core* suggests several possible course organizers. Evolution, for example, could be one of several possible courses under the heading of "Great Ideas of Science." The NSTA envisions integrated courses as being more popular in middle schools.

Another route, which high schools might find more attractive, would retain *discipline-based courses* but restructure and reorganize them to yield better coordination. One possible approach would be for students to attend one to two classes each week in each science, taught by the most appropriate teacher for that science. Teachers would jointly plan the curriculum to ensure appropriate linkage and coherence. A second possible approach within the discipline-based framework would be for students to take a quarter-year course in each of the four disciplines each year.

Of course, deciding on the broad organization of the science program still leaves the question of precisely what major topics and concepts from each discipline will be taught, when, and to what level of complexity. *The Content Core* attempts to lay out the topics any good science program should offer in grades 6–12. For example, an entry in the chemistry section on "atoms" proposes that students in grades 6–8 study the rationale for a particular model; pupils in grades 9–10 study the structure of the atom and the atomic structure of the Periodic Table; and students in grades 11–12 study the quantum model. *The Content Core* includes topical charts for each of the four disciplines as well as narrative explanations of each entry.

NSTA officials stress that *The Content Core* is *not* a curriculum, nor is it a list of everything in science that needs to be taught in grades 6–12. Instead, it is a possible starting point for curriculum designers to create new types of science courses reflecting the SS&C philosophy. "It's a guide for the curriculum," says Martin Apple, national project manager for the SS&C program. "It's a way to look at how you might design your curriculum for the future."

Copies of *The Content Core* are $15 each (plus $3.50 for shipping and handling) from the NSTA, 1742 Connecticut Ave., N.W., Washington, DC 20009; 202/328-5800.

they've heard. "That's where we're really seeing lots of gains," says Yager. "The students may not know a concept like density any better, but they are able to apply it to new situations better."

Questions Remain

Broader acceptance of the new science programs envisioned by SS&C still will require overcoming formidable obstacles, however.

Many of the pilot settings, for example, are middle schools. At these sites, the usual strategy is to gradually move SS&C, grade-by-grade, into high school. For several reasons, experts say, implementation may be far tougher in high school, especially at the 11th and 12th grades. An obvious pressure is preparation for college. NSTA officials and state SS&C directors are working with college representatives to explain the program. In California, Sachse anticipates that 80–90 percent of the schools that petition to have SS&C courses recognized by the University of California system will have them approved (applications were still pending when this *Curriculum Update* went to press). But a smooth transition for college-bound students in SS&C programs is not assured.

Some of the pilot sites, moreover, are struggling to meet a fundamental SS&C goal: finding alternatives to tracking so that all students have access to an appropriate core science program. SS&C "advocates that instructional strategies should be appropriate for heterogeneous groups, with no tracking," according to *The Content Core*, an NSTA report on the project. Several of the sites contacted by *Curriculum Update*, however, continue to offer different science courses to different groups, keeping such designations as "remedial" or "honors" sections. Students' willingness to do homework, their prior achievement in science, and their English-language proficiency, as well as parental pressure, were commonly cited reasons for continuing some form of tracking.

A teacher at one school was asked whether the continued use of ability groups in his school meant that SS&C courses may not be feasible for all students. "I would invite people who say that to take remedial kids and honors kids and put them into the same class," was his frustrated reply. "It won't work."

The difficulty of ensuring untracked classes at the SS&C pilot sites suggests it will be even harder outside the project's purview. "I think it will be a long time before parents of college-bound children would support doing away with the elite courses," says Iris Weiss, president of Horizon Research, Inc., which is helping to evaluate the SS&C project. On the other hand, not having the top students in SS&C courses could turn them into a dumping ground for the science have-nots. "The death knell for SS&C will be if it becomes known as the courses that the not-so-bright kids take," Weiss warns.

Will Tests Change?

Another challenge to SS&C implementation is assessment, experts note. Although "authentic" or "performance" assessment has gained considerable rhetorical support across the country, the development and actual use of these tests lag behind demand. Current standardized tests, though, aren't well equipped to measure how well students can conduct an experiment or integrate knowledge across science disciplines. SS&C course goals could go by the wayside "if kids understand that what *really* counts is how they do on a traditional 50-item multiple-choice test," says Yager. Some of the SS&C pilot sites are developing their own performance assessment tasks, and NSTA is assembling a compact disc, interactive assessment program.

Although considerable work remains to be done to respond to such challenges, those involved in the SS&C program say they are committed to this new approach to science instruction. "My biology class was a good biology class," sums up Downing, the Monte Vista teacher. "This is better." ■

For more information on the SS&C project, contact the National Science Teachers Association, Scope, Sequence, and Coordination, 1742 Connecticut Ave., N.W., Washington, DC 20009: 202/328-5800.

Project 2061: Mapping the Long Path to Science Reform

While some school reforms might be considered short-sighted, that's not a criticism many are making about Project 2061, the massive reform effort of the American Association for the Advancement of Science (AAAS).

Named in reference to the year that Halley's Comet will next appear (it last appeared in 1985, when the project was initiated), Project 2061 has consistently taken a deliberative approach to reforming science education. Explains James Rutherford, who directs the project: "Instead of starting with how to fix what's wrong with the system, Project 2061 invested three years reaching consensus among scientists and educators on what all students should end up knowing and be capable of doing in science, mathematics, and technology." A major report issued in 1989, *Science for All Americans*, established those student out-

Courtesy Fairfax County Public Schools/Randy Wyant comes; "now, a system must be designed and instituted that produces them," Rutherford says.

The breathtaking scope of the Project is an obvious reason for the cautious implementation schedule.

Unlike other science reform efforts, for example, Project 2061 considers science education to include all of the natural and social sciences, mathematics, technology, and engineering. And the AAAS has agreed to produce an impressive array of materials over the next few years to support its vision of scientific literacy.

Phases of Change

Project 2061 comprises three major phases. The first phase served to define scientific literacy by spelling out the knowledge, skills, and habits of mind that all students should acquire as a result of their K–12 education. That phase culminated with the publication of *Science for All Americans*.

Phase II began with the selection of six diverse locales to undertake the work of determining how the outcomes in *Science for All Americans* might be planned for in a curriculum appropriate for all students. Teams of educators at the six sites—Elbert, Greene, and Oglethorpe counties in rural Georgia.; the small town of McFarland, Wis.; a cluster of four districts around San Antonio, Tex.; and the urban centers of Philadelphia, Pa., San Diego, Calif., and San Francisco, Calif.—have been attempting to map different roads to the AAAS vision of scientific literacy. At least 25 educators at each site, including teachers at every level, principals, and curriculum specialists, receive up to 40 days of released time per year to work on the project.

Several products will result from the Phase II efforts, according to Rutherford.

The first is a set of "benchmarks," expressions of learning outcomes for grades 2, 5, 8, and 12, written in some detail. The pilot sites spent considerable time on a process known as "backmapping," investigating what the outcomes listed in *Science for All Americans* (for 17-year-olds) imply for structuring earlier learning experiences. A completed set of benchmarks is expected next year.

Curriculum Models

The second product of Phase II is a set of curriculum models that suggest different ways that the ultimate outcomes and benchmarks might be addressed in a curriculum. The six sites are developing a common "framework" to describe design features of the curriculum models. The models will then represent "worked-out illustrative examples of the kinds of curriculum that can flow from the application of these frameworks," Rutherford stresses—they will not yield a syllabus or an actual curriculum. Rutherford says that work at the six sites will probably yield a total of four different models (see "Four Possible Models").

The third major result of Phase II is a computer database that will be created to help school districts that wish to learn more about the myriad aspects of Project 2061 and its various components. Eventually, the resource database is expected to be interactive: thus, school districts might be able to design their own curriculum using all the building blocks developed by the Project 2061 teams. The database is expected to contain a wealth of information, including research on child development, suggestions on curriculum resources, and teachers' own comments on how various tactics succeeded or failed.

Finally, a set of 11 "blueprints for reform" are currently being drafted to suggest how various components of the education system must be changed to support the ambitious ideas about scientific literacy laid out in Project 2061. Expected to be completed next year, the blueprints will address such topics as teacher education, assessment, school organization, and higher education.

If Phase II sounds challenging, it's only a prelude to the even more ambitious goal of Phase III: encouraging districts and states to move toward the radically different vision of science education illuminated in the first two phases of the project.

Some Impact Seen

Because the findings emerging from Project 2061 are not being implemented wholesale in any schools yet, it's impossible to gauge how the project's database, blueprints, and other resources ultimately will fare in classrooms. But Rutherford and others point to several ways that the project's philosophy and initial statements of learner outcomes are having an influence in the field.

For example, several of the broad themes of science outlined in *Science for All Americans*—such as evolution, patterns of change, scale, and systems—have been adopted in the most recent California curriculum framework. California's frameworks, which are used to guide such areas as assessment and textbook adoption, are considered influential beyond the state's borders, in part because the state represents such a large market for textbook publishers.

The outcomes from *Science for All Americans* and the benchmarks being drafted also will be considered in planning the 1994 science tests to be administered by the National Assessment of Educational Progress. And, perhaps most promising, officials of the National Academy of Sciences are studying these outcomes and benchmarks as part of their effort to establish national standards in science (see

Four Possible Models

All the curriculum models being developed by Project 2061 teams are designed to address the learning outcomes in *Science for All Americans*. But they take different paths to do so. Conceptual characteristics, more than organizational or pedagogical considerations, offer the most distinction between the various models, according to a Project 2061 briefing paper. At this point, four conceptually different models have emerged:

A model emphasizing "how the world works" would center on explaining natural phenomena, objects, and processes of interest to students. As students progress, these explanations would involve more scientific and engineering principles and quantitative thinking.

An "inquiry" model would address much of the same content but would emphasize science as a way of knowing. The approach might include historical case studies, for example, and the conducting of real research in the natural and social sciences.

A "design" model would emphasize thinking common to engineering, the solution of real problems for which there are no ideal solutions, and understanding technology.

A model highlighting "human concerns" would emphasize interdisciplinary studies that could address the humanities in addition to science and technology. Students would be encouraged to view issues such as the environment or health through various conceptual lenses.

James Rutherford, director of Project 2061, says the completed curriculum models should be available in 1994. ■

pp. 7–8). National standards are expected to have a substantial impact on states wishing to align their curriculum and assessment programs around a consensus-based vision of best practice in science.

Rutherford says Project 2061 is not risking the quality or comprehensiveness of its work by rushing. "We believe that by the end of the decade, the problems [in science education] will still be out there," he says. By then, he adds, the matched products (curriculum models, benchmarks, blueprints, computer database, and so on) will be "polished" and ready for implementation. "These will be enormous contributions" to helping schools ensure that students exhibit the scientific literacy called for in *Science for All Americans*. ■

For more information, contact Project 2061, AAAS, 1333 H St., N.W., Washington, DC 20005; 202/326-6666.

National Science Standards Will Align Change, Experts Hope

Findings from both the SS&C effort and Project 2061 are contributing to a third national effort to help institutionalize new views about science practice.

Capitalizing on the momentum of the mathematics community's successful establishment of national standards, experts are now launching a similar effort in science. When completed in 1994 (according to current plans), the standards will present a consensus-based, coherent vision of the new goals for science education, say supporters of the effort. The National Research Council (NRC), the principal operating arm of the National Academy of Science, is coordinating the project, which will yield standards in the areas of curriculum, teaching, and assessment.

"National standards for science curriculum, teaching, and assessment will represent the criteria upon which curriculum, sound practice, and judgments about student work can be based," according to an NRC briefing paper. "They can and ultimately will influence the context in which every student and teacher functions. Thus, we need standards to identify, reward, and defend sound practice."

"There has to be some means for creating expectations and accountability," adds John Rigden, director of standards development for the National Committee on Science Education Standards and Assessment, the group that will oversee the development of the standards. "There have been no standards, either implicit or explicit, in science." The science standards, like those developed by the National Council of Teachers of Mathematics, will represent guidelines for schools, districts, and states—they are not mandated or enforced from the national level. But if large-scale testing programs begin to incorporate the standards, to cite one possible result of the national effort, local programs would be unlikely to ignore them, observers say.

New Vision Cited

The new standards will represent a vision of the kind of science education supported by science teachers, scientists, and the public, according to the NRC. Working groups will draft standards in each of three areas:

Curriculum. These standards will be narrative descriptions of what every student should understand about science and its applications. These learning outcomes will become the criteria by which specific state and local curriculums, learning opportunities, and assessments will be judged.

Teaching. These will be criteria for guiding the development and selection of teaching strategies to achieve the goals of the curriculum standards. They will recommend alternative approaches that can be used to make qualitative judgments concerning, for example, the development of instructional materials or the preparation of teachers.

Assessment. These standards will serve as criteria to guide the development and implementation of student assessments and program evaluations.

Working groups in each area have been named and have embarked on their task. The curriculum group is working slightly ahead of the others; it hopes to complete a draft paper this fall. An inclusive critique and consensus process will be used to help shape the reports of the various working groups. Draft versions of the standards are expected to be published next year, with a finished, complete set of standards available in 1994.

"People want a clear and coherent set of expectations [for science programs] right away, or very soon," notes Henry Heikkinen, who chairs the working group on curriculum standards and is director of the Mathematics and Science Teaching Center at the University of Northern Colorado at Greeley. Many states and local districts are trying to tie their curriculum, assessment, and teaching efforts to a widely supported common vision, he says, adding that the standards effort could help satisfy this need. In addition, because the standards project will address curriculum, teaching, and assessment in a coordinated fashion, NRC believes it will be better able to drive systemic change in science education.

Consensus Sought

Whereas several different projects suggesting new ways of teaching science have been launched recently, the NRC effort will help to unify different strategies and disparate stakeholders, officials say.

Although the major projects undertaken

by both the National Science Teachers Association (NSTA) and the American Association for the Advancement of Science (AAAS) attempt to spell out roughly what major science concepts and principles every student should master, neither group began its effort with national science standards in mind, NRC officials point out. NSTA's *The Content Core* is a scope-and-sequence document, Rigden notes, and AAAS' *Science for All Americans* suggests science learning outcomes for 17-year-olds but not for younger students (although Project 2061 sites are currently developing such "benchmarks"). "We are making use of these materials," says Rigden, but they are starting points for the effort and cannot be adopted wholesale. NSTA Executive Director Bill Aldridge and Project 2061 Director James Rutherford both serve on an advisory group to the standards project.

Richard Rau

The standards effort in science must address one issue that did not burden the establishment of mathematics standards: the presence of various disciplines (biology, chemistry, and so on), each vying for influence. However, NRC officials are hopeful that their project will yield a consensus document representing the collective support of science educators. All the major science groups are represented on an advisory panel, and the working groups contain experts from each discipline (among others). Just as important, NRC officials are getting input from representatives of numerous national groups, including ASCD. Policymakers also serve on several of the standards panels.

"We're trying to engage all the stakeholders in the conversation to begin with," says Elizabeth Stage, director of the critique and consensus process for the standards effort. "It's fine for the science teachers to say what's best practice," she adds, but legislators and others must support changes to make such practices possible.

A Question of Detail

Those involved in the science standards effort also will have to decide how detailed they should be, particularly those developed for curriculum. The notion of local control of curriculum still is widely supported, despite numerous national efforts over the past decade to present a more common conception of what students should learn. This may have led some reports to be overly cautious. Although the mathematics standards have been widely applauded, for example, some feel that the statements made in the document are too general.

"There are difficulties with either extreme" of generality or specificity, notes Heikkinen. A statement that is too general is likely to be ignored. On the other hand, if the curriculum standards are too detailed, for example, isolated "factoids" might be culled at the expense of curriculum coherence. In any case, he stresses that the end product of the group's work will not be a curriculum, but a variety of pathways and guideposts for curriculum and assessment developers.

Ultimately, the biggest question about the standards effort is whether it will leave its mark on the multitiered educational enterprise, given the preponderance of local curriculums, tests, teacher preparation practices, textbooks, and so on. Proponents cite as hopeful the rising support for a national system of standards and assessment, which has the backing of President Bush and the bipartisan National Education Goals Panel (at press time, Congress was still considering legislation on national standards and testing). But a tremendous infusion of resources is likely to be needed if all students and teachers are to meet high standards.

While acknowledging such challenges, those involved with the standards-setting effort in science are optimistic it will contribute to needed changes in science classrooms. "There's clearly a need for change" in science education, says Karen Worth, senior associate at the Education Development Center and chair of the working group developing teaching standards. "This is a moment of real possibility, and the standards will be an important piece." ■

John O'Neil, Editor
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Developing Leadership for Quality in Education for All Students

ASCD CURRICULUM Update

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