Implementing the National Science Education Standards

How will we know when we're there?

WHEN THE *NATIONAL SCIENCE Education Standards* was released in 1996, members of the science education community embarked on a journey—one they hoped would result in higher levels of science literacy for all the nation's students. Constructed by tens of thousands of people who were engaged in the writing, review, and consensus-building processes, the Standards is a guide to strategies, structures, and policies that support world-class science education. The Standards specifies teaching, assessment, professional development, program, and system standards and perhaps most important, it sets content standards that provide a set of ambitious learning goals for all students.

The importance and role of standards in education reform have been reaffirmed on a regular basis. At the 1996 National Education Summit held by state governors and leaders of some of the nation's largest corporations, more than 80 percent of states agreed to set globally competent science education standards. Business leaders agreed that hiring practices must include school-related performance, and President Clinton specifically alluded to the positive influence of the science Standards.

Over the past year, discussion of the results of the Third International Mathematics and Science Study (TIMSS) suggests that a rigorous set of standards that establishes a single and shared vision for science education in this country could improve the achievement of our students in comparison with students around the world (National Center for Educational Statistics, 1996, 1998; Schmidt, et al, 1996). The power of standards to influence curriculum, instruction, and assessment, and to create a focus for professional development, program improvement, and system change can help implement the vision of a world-class, K–12 science education system in the United States (Bybee, 1997).

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EMBRACING THE STANDARDS

The Standards has support at local, state, and national levels. Although voluntary, the *National Science Education Standards* has been adopted in full by many states and local communities. States that set their own standards have used the *National Science Education Standards* for rigorous and far-reaching guidance for their challenging task (Council of Chief State School Officers, 1997).

However, there has been criticism, which should not be ignored, of current standards. Some educators have voiced reservations about the attention being given to standards when larger social problems are being neglected (Nodding, 1997). Debates in California about the nature and content of standards engage the public and scientists alike. Yet the concerns appear not to be whether standards should exist but what their purpose

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should be and what they should contain. Several books provide insight into and support for the role of standards in the improvement of U.S. education (Ravitch, 1995; Rothman, 1995; Tucker and Codlings, 1998).

THE CHALLENGE OF IMPLEMENTATION

Since the publication of the *National Science Education Standards* and the endorsement of standards in general at both the state and national levels, the time has come to pay full attention to the task that is even more difficult than setting standards: implementing them. Standards on paper are useless without actual changes at all levels. As Diane Ravitch, a respected scholar of American education, commented about the 1996 Education Summit, "Folks, we still don't have standards. We just have talk." Two years later, we add, "Now we have standards; let's get on with it!"

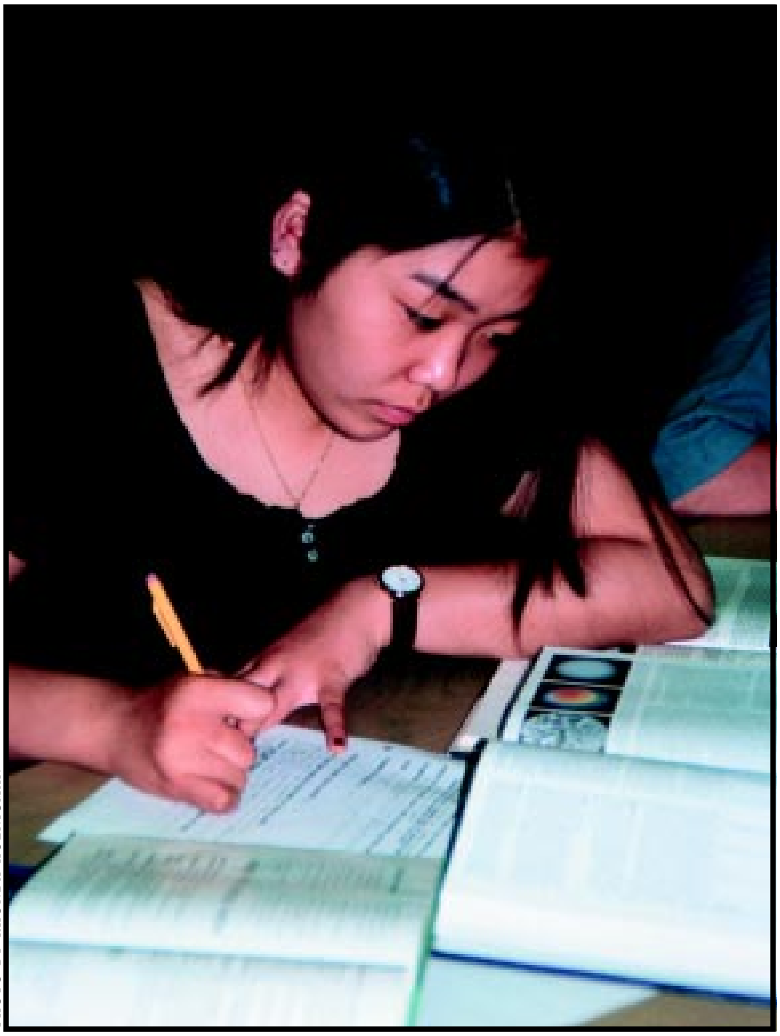
Before implementing the Standards, a short pause is warranted. At this stage of the journey, it is imperative to determine how we will know when we have completed this task. The ultimate answer is that all students will have achieved the outcomes specified in the content standards. But at intermediate points along the journey we need to ask questions such as, "If we are successful in 2, 5, or 10 years, what will look different? If we look in classrooms, schools, and communities, what will we see that is different from today?" Such visualization is necessary to keep sight of our objectives. Science teachers simply do not have the time or money to waste making changes without a clear image of their destination and the intermediate points along the journey.

The question, "How will we know when we're there?" must be asked of each new educational reform. This question should be addressed from a foundation that includes the *National Science Education Standards*, the research evidence on educational change and curriculum reform, and early work on indicators of the quality of science education. The question is one we have been asking ourselves and our colleagues since we began developing, implementing, and evaluating new programs, curricula, and practices in schools and classrooms.

DEFINING SUCCESS

In the mid-1970s, when large quantities of new science curriculum materials were being developed, introduced to science teachers, and implemented with enthusiasm, concerns were raised about how to measure success. Those who jumped to measure student outcomes were disappointed to find "no significant differences" when using the new materials rather than the old. Such findings often proved to be the result of prematurely measuring outcomes (Hall and Loucks, 1977).

Science teachers who were trying to do a good job with the new programs had other questions, including, "What exactly should I be doing to use this program well?" When they were trained in or purchased the program, few teachers were



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given a picture of what the changes should look like; for example, how they should organize for instruction and what roles they and their students should play. Program developers were dismayed to find the programs they had designed and tested so carefully were often being used differently than they had intended, possibly because many developers had neglected to specify what the program looked like in districts, schools, and classrooms where they had achieved the best results.

There are several reasons to define carefully what new programs, practices, and curricula look like when implemented. Careful definition of teaching practices, student and teacher roles, grouping and assessment processes, and other practices eases communication between teachers, administrators, curriculum coordinators, and developers. It helps evaluation by clarifying how to examine changes and understand their impact. It helps to monitor implementation so specific needs for professional development and support can be identified. Finally, it helps build a common vision of what science teaching and learning are all about.

One method for defining new programs and practices that has been widely used across the country for all of these purposes was called "innovation configurations." Its original developers at the Texas Research and Development Center for Teacher Education used it to study variations in implemented innovations in schools. In one study, the method was used to create a "component checklist" that examined the use of each of 61 federally supported school improvement innovations (Loucks, 1983). In the decade since these studies were conducted, the method has been used to monitor, evaluate, and provide training and support for dozens of programs and practices, including those for improving science teaching and learning (Hord, et al, 1987).

The basis of a component checklist, although sometimes not easy to accomplish, is very straightforward—identify the primary components of a program, practice, or other change by asking the question, "What would it look like when implemented?" A more vivid question we like to pose is, "If you were in a helicopter flying over classrooms, schools, and district offices, what would you see?" Component checklists can either simply list indicators of successful implementation for each component (what you would see) or they can have a "degree of implementation" scale that describes ideal implementation of a component, acceptable though not ideal implementation, and unacceptable implementation (Loucks and Crandall, 1982).

(The word "checklist" has the connotation of trivializing important elements of a program or practice, implying that if all are performed, or "checked off," implementation is successful. Here we use this label to point out elements that should be considered. Some elements may ultimately be ignored, but the decision to do so should be an informed and thoughtful one.)

A component checklist could assist in the implementation of the Standards; specifying what to look for in schools and, at the levels at which policies and support are formulated, allows us to monitor changes, target areas that need assistance, and evaluate progress. Armed with a way of measuring progress, we can better communicate among and beyond the education community, and we can make more informed decisions overall about how best to use limited resources to improve science education.

To use a component checklist to help implement the *National Science Education Standards*, we must ask, at each level (classroom, school, district, external support, state, and national), "What would you expect to see if the Standards were in place?" Answering this question can provide guidance for educators at each level and help those in oversight positions to assess progress and determine future steps.

Figures 1, 2, and 3 illustrate some of the "indicators" that science teachers can look for in their class-

FIGURE 1.

What would you expect to see in your classroom if the *National Science Education Standards* were in place? (Some examples.)

Science teaching standards:

- Students engaged in active and extended inquiry
- A curriculum tailored to student needs and characteristics
- Students cooperating and sharing responsibility for learning
- Teachers gathering and analyzing data about student learning

Professional development standards:

- Teachers observing each other's classrooms
- Teachers demonstrating an understanding of science concepts

Assessment standards:

- Continuous assessment and use in planning and adjusting instruction
- Use of multiple methods of assessment
- Assessments consistent with valued outcomes
- Assessment tasks that require students to apply scientific knowledge and reasoning to real-world situations and those that resemble how scientists work

Science content standards:

- Teacher goals for science learning reflect the Standards
- Curriculum materials that teach the Standards
- Teachers use curriculum framework to select and design classroom work

Science education program standards:

- Students have easy, equitable, frequent opportunities to use equipment and materials for investigations
- Students learn science outside classroom.

FIGURE 2.

What would you expect to see in your school if the *National Science Education Standards* were in place? (Some examples.)

Science teaching standards:

- Teachers working together to select and adapt curriculum materials
- Teachers discussing their students and refining teaching materials and strategies
- Teachers planning and working together
- Teachers sharing and analyzing data on student learning
- Principal supporting Standards-based teaching

Professional development standards:

- Release time available for school-based professional development
- Teachers planning together and participating in long-term learning experiences

Assessment standards:

- Assessments aligned with Standards and curriculum
- Assessments influence student assignments, teachers' roles, facilities planning

Science content standards:

- School scope and sequence aligned to the Standards
- Course syllabi teach the Standards
- The criteria for selection of instructional materials align with the Standards
- Content matrix and materials articulated across grade levels

Science education program standards:

- Science program leadership roles specified
- Teachers have time to plan and execute lessons
- Access to appropriate materials and equipment

rooms, schools, and districts. We include the district because teachers are increasingly being called upon to serve as members of district-level curriculum, professional development, and program development committees; as providers of professional development and other support for their peers and preservice teachers; and as representatives of science education reform for the community. Without having considered which changes are needed at all levels, teachers may feel unprepared to serve in these roles. This list could be expanded to include what to look for at state and national levels as well as organizations that support schools, including universities and colleges, technical assistance centers, informal science education organizations, businesses, community organizations, intermediate agencies, and the Eisenhower Consortia and Eisenhower National Clearinghouse. As is clear from the program and system standards of the *National Science Education Standards*, actions and support from all levels are required if change is to occur and be sustained.

The points listed in Figures 1–3 are only suggestions. Because local contexts vary so radically, with different state policies, student populations, and resources, it is impossible to create one definition of success. In these figures, however, we suggest some starting points for local educators interested in defining success. Used in active dialogue, these can help people and organizations at each level ask the all-important question, "What are some ways that we can contribute to science education reform and achieve science literacy for all students?"

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FIGURE 3.

What would you expect to see in your district if the *National Science Education Standards* were in place? (Some examples.)

Science teaching standards:

- Written instructional guidelines support Standards-based teaching
- Teacher rewards and evaluations based on the Standards
- Teachers hired who demonstrate Standards-based teaching

Professional development standards:

- Professional development resources spent on Standards-based professional development
- Support for long-term professional development opportunities

Assessment standards:

- District-wide assessment of student achievement of the content standards
- Assessment of opportunities for students to learn science aligned with the teaching, program, and system standards

Science content standards:

- Criteria for selection of instructional materials based on Standards
- Curriculum goals and framework reflect the Standards

Science education program standards:

- The statement of goals for science program includes philosophy, vision, and purpose
- The district science program includes all content standards
- The curriculum framework, based on Standards, guides selection and development of units and courses of study
- Explicit connections are made between science and other school subjects, particularly mathematics
- Alignment of student goals and expectations, curriculum, assessment, teaching practices, support for teachers
- Careful articulation between levels of schooling
- Science program leadership roles specified
- Policy documents specify resources, opportunities for professional development, and leadership to support goals of science program

Science education system standards:

- Teacher employment, evaluation, and professional development policies and practices are congruent with Standards
- Policies and practices that affect science education are coordinated across the district
- Policies and practices are regularly reviewed for impact and unintended effects
- Clear, accessible, frequent information flow
- Resources for reform include adequate time in school day, exemplary teachers, frameworks, facilities, equipment
- Policies provide equitably allocated resources for students with special needs

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