

## ● Implementing the National Science Standards

by Juliana Texley. Ph.D.

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Teachers are used to working with standards. Planning curriculum, defining expectations, and grading students' performance are all part of a day's work. But in the early 1980s, when a series of more than 300 national studies and reports criticized mathematics and science education in the United States, it was the absence of standards that was most often cited as a major failing.<sup>1</sup> Businesses, governments, and social observers charged that across the nation there was no consensus on what American teachers should teach, how they should teach, or how they should assess students' performance.

**Disturbing Headlines** During the 1980s, the national education "inferiority complex" made frequent headlines. American students scored at the bottom of international tests. College students in other countries outperformed American college students in undergraduate course work. Our science, engineering, and technology businesses lacked competent employees. Education experts concluded that before the situation could begin to change, the nation would have to reach a broad agreement on what our school systems should teach students in mathematics and the sciences.

**Everyone Has a Say** With this challenge, mathematics educators came together relatively quickly to produce a series of new and challenging mileposts by which we could measure a world-class national curriculum.<sup>2</sup> Science educators, on the other hand, took 13 years to come to agreement on a similar set of standards. The path wasn't an easy one. While educators looked for a curriculum model that was broad yet had a depth of content, experts in different fields lobbied hard for their disciplines to be given prominence in the curriculum. Research scientists lobbied for deep content, while educational researchers sought to embed the best inquiry methods into the science standards. Constructivism, the theoretical foundation of much of today's education theory, was being labeled "fuzzy thinking" by many scientists.

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**Back in the Schools . . .** With this flood of input, it was no wonder the first draft of the National Science Education Standards was more than 300 pages long!

But while dozens of national groups argued about the form and substance of the standards, educators began the work. Even without a national document, science teachers knew the goal—to produce a scientifically literate and economically successful population. Hundreds of science standards projects were generated by school districts, colleges, and other interested groups while the standards committees continued their work.

**Consensus!** Presented by the National Research Council in 1996, the National Science Education Standards codified a consensus on the best in science education. The standards were created by a broad and comprehensive body of contributors and, like the mathematics standards, the science standards were intended to drive and reform both institutions and curricula.

**Six Components** What set the science standards apart from the mathematics standards was the simultaneous treatment of six distinct components of education. Many earlier standards projects had considered individual or small groups of factors in education. The science standards, on the other hand, acknowledged that in order to create real change, the nation's educators have to consider and address many of the factors influencing education. These factors include *teaching techniques, student assessment, professional development, content, programs, and educational systems.*

**Practical Value?** By addressing our entire educational system, the standards aimed to avoid the lack of coordination that had plagued science curricula in the United States for so long. However, because the standards were written for such a diverse audience and addressed so many different issues, many teachers were left wondering if they would be able to put the standards into practice.

### The Morning After

The release of the National Science Education Standards made national news. But when the applause died down, it was left to teachers in classrooms to turn the standards into reality. After 13 years of debates and false promises, many science teachers received the final draft of the science standards with mixed emotions—relief that the profession was finally speaking in one voice after so long, and confusion as they wondered, “Now, how do I do it?” Would the hard work and reforms of the past 13 years be discarded? Would teachers be forced to change the way they ran their classrooms? Would teachers be able to respond to the mandate? The task of implementing the science standards, which at first glance seemed simple, suddenly looked very complex.

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**Transforming the Vision** In an effort to respond to teachers' concerns, the NSTA mobilized a large cross-level committee whose purpose was to transform the vision of the standards into practice. The committee's first task was to help science teachers understand what the standards were and what they were not. The committee's purpose was also to link the standards to the hundreds of quality-reform efforts carried out in the years between the publication of *A Nation at Risk: The Imperative for Educational Reform* and the science standards. The project, called *Pathways to the Science Standards*, linked more than 700 existing projects and grant-funded programs with the standards and showed teachers how to move forward from their present practice to the vision of the National Research Council.

**A Short Leap** In a huge understatement, the authors of the science standards tell teachers that "some outstanding things happen in science classrooms today, even without national standards."<sup>3</sup> In fact, every teacher has some methods and every classroom has some materials that already reflect the science standards. The challenge for teachers is to identify and utilize the practices and materials that are "standards compatible" and to modify current practices to make them even better. The *Pathways* project emphasized that most modern textbook series and most commonly available materials can be used in whole or in part to meet the challenge of the science standards.

**A Different Angle** Science standards challenge teachers to see their own teaching habits and techniques with a new vision. For instance, a favorite hands-on Earth science lab might successfully teach students the names of some rock formations, but it does not encourage students to think about where the formations came from. Consider the differences between two sets of laboratory directions for a familiar experiment in cell biology, which is on the next page.

### Practical Steps for Moving Toward the Standards

The pathway from traditional hands-on laboratories to more open, standards-based practices is not a long one. Nor is the change particularly difficult, especially if teachers have the confidence to examine their own techniques and the patience to get good results by taking it one step at a time. To move existing teaching practices toward the science standards, consider the following practical steps.

#### 1. Look at your goals for the year.

Narrow the content goals, and add goals in process and skills development. If your district expectations are unrealistic, become an advocate for change.

(See *Teaching Standard A*)

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Laboratory Directions: Before and After Standards		
Traditional laboratory	Standards-based approach	Links to the standards <sup>4</sup>
We will investigate the efficiency of each cell model to absorb a solution. Iodine will be used as an indicator of starch.	How can we measure how well each cell model absorbs ions? Can you find an indicator that will clearly identify the parts of the starchy potato that are touched?	<b>Sharing responsibility with the “community of learners”</b> <i>Teaching Standard E:</i> “Enable students to have a significant voice in decisions about the content and context of their work . . .”
Cut a potato into three cubes, 0.5, 1.0, and 1.5 cm on a side.	From a potato, cut three cubes of different sizes, and calculate the surface area and volume of each cube.	<b>Constructivist discourse and decision making</b> <i>Content Standard A:</i> “As a result of activities in grades 5–8, all students should develop abilities necessary to do scientific inquiry [and] understandings about scientific inquiry.” <b>Integration with mathematics</b> <i>Program Standard C:</i> The K–12 “science program should be coordinated with the mathematics program . . .”
Calculate the percentage of volume absorbed, and place your answer on the chart.	Calculate the percentage of volume absorbed. How accurate is your result? What are the similarities and differences between your model and a real cell?	<b>Imbedding assessment and self-evaluation</b> <i>Assessment Standard C:</i> “The technical quality of the data . . . is well matched to the decisions and actions taken on the basis of their interpretation.” <i>Teaching Standard B:</i> “Challenge students to accept and share responsibility for their own learning.”
Review your results and prepare for a test.	At home tonight, compare the drying power of an old shirt and a terry cloth towel. How does your work today help you explain your results?	<b>Unifying Concepts . . . “form and function”</b> <i>Content Standard K–12:</i> “Students should be able to explain function by referring to form and explain form by referring to function.”

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**2. Look at last year's lesson plans.**

Highlight the exercises or methods that were most successful. They're probably already "up to standard." If you are using a new program this year, find ways to integrate what has worked before into the new materials.

*(See Teaching Standard A)*

**3. Explore your students' preconceptions about new topics before they are introduced.**

Use open questioning, journal or brief oral responses, or group dialogues. Open up your discussions to allow students to challenge, question, or simply clarify concepts.

*(See Teaching Standard B)*

**4. Check students' understanding.**

Embed assessment into every lesson. Interrupt your normal lesson plan for a written response or group dialogue, or ask students to draw a picture.

*(See Teaching Standard C)*

**5. Add a real-world extension to each laboratory or classroom experience.**

Add time to your program by developing homework assignments that connect classroom experience to familiar surroundings. Bring parents and the community into the process of extending meaning for students.

*(See Teaching Standard D)*

**6. Look at the labs that are most successful for you.**

Are there safe ways to let students make their own decisions about parts of the procedure? If so, rewrite those portions. Encourage students to use the methods of scientific research to modify their own work or to develop procedures to answer their own questions. Don't be afraid to explore questions whose answers you do not know.

*(See Teaching Standard E)*

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#### **7. Reduce but don't completely eliminate direct, lecture-based instruction.**

Include inquiry-based labs in each lesson. When lectures are the most appropriate method of content delivery, find ways to intersperse experiences, quick illustrations, or student-to-student dialogues to involve students in the process and to encourage more-active learning.

*(See Teaching Standard E)*

#### **8. Find ways to learn more about your students' differences in background, learning style, or opportunities to learn.**

To every successful exercise that you have in your repertoire, add an extension or companion exercise that supports another learning style. For example, add a journal analysis to a good lab or a group discussion to a favorite lecture.

*(See Teaching Standard F)*

### **Beyond the Teaching Methods**

The applications of the science standards are not limited to teaching methods. For example, in a school that needs more time for science classes, the standards advocate block scheduling. But when block scheduling isn't possible, the solution may be found in more efficient classroom management or in a teamed, cooperative time-sharing system with a mathematics teacher. If funds for traditional professional development are lacking, the standards support a request for peer coaching or a proposal for action research in classrooms. For the teacher facing an underresourced and overcrowded classroom, the standards address the need for sufficient space and equipment. Although to some the facility guidelines may seem impossible to meet, they can still be useful to teachers in working with administrations to set goals and priorities. For most teachers, the key to reaching the National Science Education Standards will be taking the first few steps and proceeding with confidence.

### **The Content Standards**

As the standards speak to audiences of policy makers and funding agencies, they also give teachers a powerful call to become advocates for their own profession. Probably the most difficult challenge to the teacher-advocate is the call to reduce the amount of content taught in science classes. Despite the standards' foundation in constructivist educational research and the emphasis on inquiry, the standards still emphasize the importance of a strong content base. In fact, one of the most powerful, if controversial, statements made by the authors

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of the science standards is that students learn science *only* “in the context of content.”<sup>5</sup> The content core is narrower and deeper than that of most previous models, but it is still substantive. Because tomorrow’s textbooks will probably cover as much content as today’s, the standards encourage teachers to choose from the content available to them in their textbooks and to spend relatively more time on the areas they choose. To that extent, the model curriculum reflected in the content standards can be a good support for teachers when they are deciding on content.

#### **The Professional-Development Standards**

The professional-development standards demand lifelong support of the nation’s educators, placing special emphasis on the content and inquiry methods of research scientists. They also legitimize new and expanded models for professional development, including externships in industry or government agencies and action research in a teacher’s own classroom. By making these statements, the standards support new kinds of grant proposals and new uses for professional-development funding, including Eisenhower and Title I funds. The science standards also speak eloquently for equity in education by encouraging every educator to explore, evaluate, and improve students’ opportunities to learn within their home and school communities. The standards make a powerful case for compensatory education. By encouraging diverse methods, the standards not only tell teachers why they must enhance equity but also explain how it can be done.

#### **The Program and Systems Standards**

The program and systems standards acknowledge that neither teachers nor school systems can implement the science standards alone. For perhaps the first time, there is a high-profile acknowledgment of the responsibility of state and federal educational bureaucracies to become part of the solution rather than part of the problem. For instance, the program standards demand that students have equal access to sufficient resources (Program Standard D) and equitable opportunities to achieve (Program Standard E). The system standards demand that the mandates of systems be supported with resources (System Standard D) and that policies be equitable (System Standard E) and allow for adaptation by individual communities (System Standard A). The system standards also acknowledge that too often in the past what was intended to be a positive change at the state or federal level produced negative effects in classrooms (System Standard F). For example, a new state test intended to increase achievement actually lowered the achievement level of students on objectives that were not

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tested. The systems standards insist that those who implement policy decisions should involve teachers in the review of those decisions to avoid unforeseen consequences.

#### **A New Optimism**

By examining the barriers that school systems unintentionally raise to hamper the progress of teachers, the National Science Education Standards have created a new optimism. This is especially true among veteran teachers who have seen the reforms of the 1960s (“The Sputnik Era”) and 1980s (“The Back to Basics Movement”) come and go. The National Science Education Standards aren’t radical, but they are unusually realistic. In time, it will be possible to implement the standards in every classroom and school system. Teachers can move their educational communities forward in small steps by using the standards as mileposts, as support to validate their sound practices, and as ammunition to force systems to recognize the needs teachers have as they progress. There is reason to believe that this reform cycle will produce long-lasting results.