CHAPTER 3

An Introduction to the National Science Education Standards
by Dennis M. Bartels

Today, with the increasing demands on schools and the growing importance of science and technology, the nature of science education—what children should know and how they should learn it—may be the most important discussion of all. It is not a new question or a settled one, but it is the obvious starting point for rethinking the science education enterprise. This chapter introduces the* National Science Education Standards, *a document designed to establish a common direction for the science education system and help guide teachers and schools in achieving specific educational goals.

The American education system's greatest asset—and its worst liability—is that it is a quintessentially democratic institution. Any opinion about education, especially about what is taught and how it is taught, has a place to be heard somewhere in the system. And we all have some opinion about the American education system, because most of us are products of it.

From a teacher's point of view, this cacophony of commentary may take the form of requirements from principals, mandates from school boards, expectations from parents, guidelines from state boards of education, recommendations from superintendents—even laws from legislators. Then there are the textbook publishers, test makers, and professional development providers who have their own take on what is needed in the classroom. In the words of the old radio men, the "noise-to-signal ratio" is very, very high.

At best, these messages are mixed; at worst, they're out-and-out contradictions. So what does a teacher do? One teacher might react to these competing signals by closing the door, shutting the noise out, and doing whatever he or she feels is best for the students anyway. Another teacher might grab the nearest basal text, start from page one, and work as far through the book as possible before the school year runs out. Under the circumstances, these are both reasonable strategies.

Analysis of the Problem

This problem of policy fragmentation has resulted in a state of affairs in which a teacher (or any worker) must sort out conflicting demands from multiple constituencies and bosses. In the absence of any clear direction provided by the education system, each teacher must decide how best to navigate a course on his or her own. While some people may look to the teachers and the students when educational results do not measure up to expectations, much of the fault actually lies with those of us whose job it is to help them.

However, this picture of the problem is incomplete. It is not true that teachers lack any standards about what to teach or how to teach it. We have *de facto* standards. They are provided by textbook publishers and commercial test makers. Any teacher will tell you that what they teach, and how they teach it, is most influenced by the instructional materials they use and what their students are asked on “the tests that count.” Those tests, of course, are the ones we all read about in the daily newspapers: the SAT, Stanford-9, Iowa Test of Basic Skills, and so on.

What is wrong with this picture? For commercial producers of texts and tests, the problem is a simple marketing dilemma: What is the education marketplace buying? In the absence of any standards, the response is *everything*! If I am a commercial producer of textbooks and every state has different (or no) standards, and there are 14,400 school districts, each with its own educational goals, and 85,000 schools all wanting different books with different concepts emphasized, my best strategy is to put everything under the sun into those texts and tests.

The result of this strategy is the creation of materials that provide a superficial treatment of most things, and in-depth coverage of very little. Hence the primary criticism pointed out in the latest Third International Mathematics and Science Study (TIMSS), that the American school curriculum is a “mile wide and an inch deep” (Schmidt, McKnight, and Raizen, 1997, p. 122).

Think back to the days when you or your parents attended school. Science textbooks averaged half an inch to one inch in thickness. Today, the average is more like two inches—and growing.

In fields like science, where new knowledge is doubling every few years, this is an acute problem. You could keep a student in class for 12 straight years, 7 hours a day, just studying science, and still not cover the whole expanse of the topic. Moreover, by the time the student finished, half of what he or she just learned would have become obsolete! So who decides what science is most worth learning and why? What is essential knowledge in science?

Enter the Standards

What if we had nationally developed standards in each of the academic disciplines that were concise and clear and generally acceptable to everyone? We might agree, for instance, that by the end of the third grade, students should understand that there are three states of matter—liquid, solid, and gas; or by the time they graduate from eleventh grade, they should be able to explain the social, economic, and political factors that led to any major American war. In order to develop these standards, we would need to determine, in a rigorous way, what types of knowledge are most essential to each discipline, and then convince the majority of the rest of us that these are reasonable things for most of us to learn.

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That is exactly the process that the National Research Council embarked on in 1992 to produce the *National Science Education Standards* (see sidebar on page 22 for details). It is also similar to the process that most every other academic discipline initiated during the late 1980s and first half of the 1990s.

The first thing to note is that these are not federal standards, as some may believe. In every case, the national education standards were driven by the primary national professional association in the discipline, such as the National Council of Teachers of Mathematics or, in the case of science, the National Academy of Sciences. These organizations are driven by the professional interests of practicing mathematicians, scientists, and teachers of these disciplines. The key to their credibility and success in creating the standards was finding the most eminent scientists, leading researchers of learning, and successful classroom teachers to draft the documents.

The best standards are a step or two ahead of where the rest of us are. They are not intended to be true consensus documents, nor do they stray into untested waters. Rather, they represent the place where the best of us have already tread. Documents of complete consensus would, by definition, represent the mathematical mean: in other words, they would be what we already have. Standards documents are meant to be vision-setting documents. That is why most, even today, remain somewhat controversial, as they ought to be.

Most important to note is that standards documents do not change educational outcomes. People do. This gets at the heart of how standards documents such as the *National Science Education Standards* are intended to be used. We do not create a state of educational nirvana by simply producing standards documents. Creating the *Standards* is the easy part (and none too easy if you ask any of those directly involved). It does not, in itself, change the systems, institutional structures, and material resources that determine instructional priorities in the classroom.

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So what good are the *Standards?* Herein lies some of the current debate. Some observers and critics argue that the science *Standards* are designed for teachers' direct use: to compare current classroom curriculum and instructional practices against specific pages in the documents. I believe this is a naive view. Teachers are bound by the policies, instructional materials, tests, and professional development experiences provided to them by others. That is why, in additional curriculum guidelines, most national standards documents also address changes to the policies, materials, assessments, and teacher preparation experiences necessary to implement these student learning standards.

With so many issues beyond their control, it does little good for teachers to compare the *Standards*, point by point, to their own teaching practice. In my view, the *Standards* are most appropriate for the rest of us in the system: staff developers, school board members, college professors who teach teachers, test makers, producers of instructional materials, and so on. If those of us outside the classroom could align ourselves with a single set of standards, the teacher's world would make much more sense. We could have system agreement and a unity of purpose at both the school and classroom level. In short, all of our actions—individually and collectively—are necessary for the *Standards* to have a positive effect on student learning.

Looking Forward

How can the science *Standards* be useful to us? Here are five contributions that the *Standards* can make for any science instructional program in the process of improvement.

1. ***To simplify the curriculum.*** The extraordinary push for coverage is one of the greatest problems in American education and leaves more and more students in the dust. No teacher has either the expanse of collective scientific expertise or the time, for that matter, to determine what is most essential for students to learn. The *Standards* should be used as much to determine what should be pruned out of the curriculum as what should be grafted in its place. We cannot keep adding without taking away. By its nature, the *Standards* solve the problem of deciding what is most important or essential to learn.

2. ***To provide a common point of reference for different and sometimes divergent interests.*** One cannot expect that teachers, parents, school administrators, political office holders, instructional materials producers, or commercial test makers will have the same interests at heart. Test makers and publishers want to sell the most units. Principals want to look good on tests. Politicians want to look like they are doing something about education reform. Teachers want their students to do well. However, to the extent that we can get all these disparate groups to agree on one thing—what is most important for all students to learn—the rest of us can arrange our world to deliver that and still win in our individual domains. This seems like a monumental task at the national level. I believe it is more possible at the local program level. Student learning standards is the right place to establish some common ground.

3. ***To argue about the right things.*** As noted, not everyone agrees with everything in the science *Standards.* But the *Standards* do provide something essential that has been sorely lacking in the education reform debates of the past: discussion about the most important parts of schooling—curriculum, instruction, and assessment. They are at the heart of the matter.

   In the 1980s, school governance, finance, restructuring, longer school days, and longer school years were all targeted for possible reform. These, I think, are interesting projects, but secondary areas of concern. They are off the mark. What good is a longer school day or year if it is just more of the same old type of instruction that produced the earlier failures and dissatisfaction? It is as if an automobile manufacturer decided to improve the performance of its cars by adding another shift to its plants. The *Standards* can help local programs stay focused on the most important products of their enterprises—student learning—and make everything else in the system subordinate to it. Arguments about what students learn, and how they learn, are worth our time.

4. ***To ensure everybody the opportunity to learn.*** Without challenging school systems to make some fundamental changes, we ensure that some students will continue to have better educational opportunities than others. In the absence of pre-set academic standards, it is easy for the educational system to allow qualitatively different learning experiences for different sets of students. The tendency is to remediate by slowing learning down, rather than accelerating a student's learning to help him or her catch up. This is not an impossible task. The military, for instance, has managed to come up with ways for (almost) all its soldiers to reach some specific standards. Without standards, excuses are easy to come by, and accountability is easy to avoid.

5. ***To lift our sights.*** Much theoretical debate has ensued in the Standards community about whether the *Standards* should be ultimately obtainable or not. Should they exemplify the Platonic state of ideals that we unrelentingly strive for, or should they be easily obtainable by most students in the near future? If you accept the argument that these are vision documents a bit ahead of their time, then some standards ought to be a great challenge to us.

That is the case for including inquiry as part of current science *Standards.* In that document, inquiry is seen as being a way to approach three important aspects of science learning: the content of science; the skills needed to carry out inquiry science; and the teaching methods used to introduce children to science inquiry. "Learning is something students do," the document says, "not something that is done to them" (p. 20).

Teaching and learning science using inquiry methods is not an unreachable goal, as examples from classroom practice (including those recounted in this book) have shown. But it is a challenging one for most of us. The *Standards* should reveal at the local level some new territory or goals that stretch science instructional programs toward genuine excellence.

The "Next Word" in Science Learning

At a recent meeting at which the nation's governors and business leaders discussed academic standards, some governors suggested that standards were not necessary for education improvement. Many business leaders were incredulous. Without standards, they asked, how do you measure success? How do you guide an enterprise to what is most important to accomplish? The question was never raised again.

It may be more important to raise the question of what all of us can do with these science standards now that we have them. The *Standards* are the "next word," not the "final word," in our attempts to improve science programs. In the true scientific sense, the *Standards* are our best working hypothesis of where we need to go. As the data from experience come in, we need to revisit and revise this working hypothesis. If excellence and scientific literacy for the general populace are our genuine goals, the *Standards* are the obvious place for us to start.

References

National Research Council. (1996). *National science education standards.* Washington, DC: National Academy Press.

Schmidt, W.H., McKnight, C.C., and Raizen, S.A. (1997). *A splintered vision: An investigation of U.S. science and mathematics education.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

About the National Science Education Standards

In 1996, the National Research Council published a 250-page report called the *National Science Education Standards.* This document has two primary organizational dimensions. The first focuses on the content of science itself and is organized by grade levels. The second focuses on major features of the educational system that need to change to bring "coordination, consistency and coherence to the improvement of science education" (p. 3).

The *National Science Education Standards* identify the essential concepts in building an exemplary instructional program in science, from kindergarten through grade 12. It also declares two fundamental tenets that establish the intent of all its recommendations: first, that the *Standards* are for all students; and second, that every student must be given the opportunity to learn science—meaning they should have access to skilled teachers, adequate classroom time, a rich array of learning materials, and so on. Both of these conditions are necessary if science understanding is to change from the province of a select minority (in particular, the college-bound), to a literacy skill for the vast majority.

The *Standards* also make the case that given current changes in the workplace and economy, science is now a basic literacy skill. It reinforces the moral commitment that everyone deserves to share in the excitement of science and technology. And, perhaps most compelling, it points out the need to make sure that every student has the opportunity to learn both the information science offers and the critical process and reasoning skills that support informed everyday choices and decisions.

In terms of science content standards, Chapter Six of the document outlines three grade-level clusters (K–4, 5–8, and 9–12), and divides each into the same eight categories:

- Unifying concepts and processes
- Science as inquiry
- Physical science
- Life science
- Earth and space science
- Science and technology
- Science in personal and social perspective
- History and nature of science

These categories outline standards for each of the grade levels identified. One standard under "physical science" for grades K–4, for instance, is for students to understand that "Light can be reflected by a mirror, refracted by a lens, or absorbed by the object" (p. 127).

The document stresses, however, that the content standards are not intended or designed as specific curricula. Instead, they "provide criteria that people at the local, state, and national levels can use to judge whether particular actions will serve the vision of a scientifically literate society" (p. 3).

Accordingly, the document also sets out criteria for all the other parts of a teacher's world. Specifically, four to seven standards are outlined for each of these five areas of the education support system:

- Science teaching
- Professional development for teachers of science
- Assessment in science education
- Science education programs
- Science education systems

"Learning essential science content through the perspectives and methods of inquiry" (p. 59) is one example of a standard for teacher professional development.

The document goes on to describe, in greater detail, what each of these standards mean by way of descriptions, examples from actual classrooms and schools, and references to research.