Foreword

By Chester E. Finn, Jr., and Kathleen Porter-Magee

Since *Sputnik* shot into orbit in 1957, Americans have considered science education to be vital to our national security and economic competitiveness. The impact of the Soviet satellite launch on American science classrooms was almost immediate. Shirley Malcolm, a leader in the field of science education (and presently head of education programs for the American Association for the Advancement of Science), was a young student in Alabama at the time. She described the swift and palpable shift in the way science was taught:

> **We stopped having throwaway science and started having real science…All of a sudden everybody was talking about it, and science was above the fold in the newspaper, and my teachers went to institutes and really got us all engaged. It was just a time of incredible intensity and attention to science.[1]**

The impact on public opinion was just as profound—and national concern over the quality of American science, and science education, has continued for the past half century. According to a 2011 survey, 74 percent of Americans think STEM (Science, Technology, Engineering, and Math) education is "very important." Only two percent say it's "not too important."[2]

Yet this strong conviction has not translated into strong science achievement. The 2009 National Assessment of Educational Progress (NAEP) found barely one-third of fourth graders in the United States at or above the "proficient" level in science, with those proportions slipping to 30 percent in eighth grade and a woeful 21 percent in twelfth grade.[3] Another recent study reported that just 30 percent of our high school graduates are prepared for college-level work in science.[4]

International comparison is even more disheartening. The most recent PISA assessment, released in December 2010, showed fifteen-year-olds in the United States ranking a mediocre twenty-third out of sixty-five countries. By contrast, youngsters in Shanghai ranked first, demonstrating both China's commitment to science education—and the various bounties that accompany it—and that nation's capacity to deliver on its educational aspirations.

Similarly, on the 2007 TIMSS science assessment, American eighth graders overall ranked eleventh out of forty-eight nations and were trounced not only by the likes of Singapore and Japan, but also by the Czech Republic, Hungary, and Slovenia.[5] Even more distressing, only 10 percent of American

[1] Cornelia Dean, "When Science Suddenly Mattered, in Space and in Class," *New York Times*, September 25, 2007, http://www.nytimes.com/2007/09/25/science/space/25educ.html?pagewanted=all.

[2] Research!America, *Your Congress-Your Health: National Public Opinion Poll* (Alexandria, VA: Research!America, March 2011), http://www.yourcongressyourhealth.org/admin/Editor/assets/yourcongress2011.pdf.

[3] Institute of Education Sciences, *Science 2009: National Assessment of Educational Progress at Grades 4, 8, and 12* (Washington, D.C.: National Center for Education Statistics, January 2011), http://nces.ed.gov/nationsreportcard/pdf/main2009/2011451.pdf.

[4] ACT, Inc., *The Condition of College & Career Readiness* (Iowa City, IA: ACT, Inc., 2011), http://www.act.org/research/policymakers/cccr11/readiness1.html.

[5] Patrick Gonzalez, *Highlights from TIMSS 2007: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context* (Washington, D.C.: National Center for Education Statistics, September 2009), http://nces.ed.gov/pubs2009/2009001.pdf.

eighth graders scored at or above the TIMSS "advanced" level. By contrast, 32 percent of students in Singapore reached that level.

The evidence is indisputable—and should be alarming. While no one test can communicate the full picture of education achievement, if our students' performance on international assessments like TIMSS and PISA is any indication, the United States is doing little more than *talking* about the importance of getting science education right.

Why is this? How can it be that, for more than five decades, Americans have voiced so much concern about science education yet made so little progress in delivering it? There are, of course, multiple explanations, starting with the blunt fact that few states and communities have taken concrete action to build world-class science programs into their primary and secondary schools. Without such programs in place to deliver the goods, our Sputnik-induced anxieties remain fully justified some fifty-five years later.

A solid science education program begins by clearly establishing what well-educated youngsters need to learn about this multi-faceted domain of human knowledge. Here, the first crucial step is setting clear academic standards for the schools—standards that not only articulate the critical science content students need to learn, but that also properly sequence and prioritize that content. In the light of such standards, teachers at each grade level can clearly see where they should focus their time and attention to ensure that their pupils are on track toward college- and career-readiness. That doesn't mean it will happen, of course. As we at the Thomas B. Fordham Institute have repeatedly noted, standards alone cannot drive outstanding achievement. But they are a necessary starting point. They are the score for conductors, musicians, instrument makers, and more. They are the foundation upon which rigorous curricula and instructional materials and assessments are built. They are the template for preparing science teachers for our classrooms.

Fordham has a long-standing interest in science standards and a history of reviewing them with care and rigor. We published our first analysis of state science standards in 1998 and a follow-up review in 2005. Unfortunately, the findings from both evaluations were not good. In 1998, just thirty-six states had even set standards for science, and only thirteen of those earned grades from our reviewers in the A or B range. By 2005, though every state except Iowa had articulated K-12 science standards, the results were equally disheartening: just nineteen earned honors grades, and the overall average was barely a C.

Why So Different?

This variability in the quality of standards is as unacceptable as it is unnecessary. As one of us observed in our 1998 review:

> **If any subject has the same essentials everywhere, after all, it's science. I can think of no sound reason why what is expected of teachers and children in biology or chemistry should be different in Tennessee…than Indiana. Indeed, it should be approximately the same as what is expected in Singapore and Germany, too.[6]**

Science is not, of course, the only core subject where it makes no sense for young Americans to be held to different standards depending on where they live. That is why the Council of Chief State Schools Officers (CCSSO) and National Governors Association (NGA) came together in 2009 to build rigorous common standards for English language arts (ELA) and mathematics. These common standards aimed to articulate the knowledge and skills that all students need to master across grades K-12 if they are to succeed in college and career. The result of this effort was the 2010 "Common Core" standards for ELA and math. Notably, these standards are clearer and more rigorous than those in use in most states. Fordham's own analysis, comparing state ELA and math standards with the Common Core standards, concluded that, "out of 102 comparisons—fifty-one jurisdictions times two subjects—we found the Common Core clearly superior seventy-six times."[7]

Today, a similar push toward quality common standards is underway for science. Twenty-six states have teamed up with Achieve, Inc. to craft "Next Generation Science Standards" (NGSS). This group intends to do for science what the CCSSO and NGA did for ELA and math: create a set of clear, rigorous, and specific expectations that states will have the option to adopt as their own. Indeed, such a movement is long overdue.

Like the drafters of the Common Core standards, Achieve and its partners will look to national and international models as starting points for the development of the NGSS. Among those models is the *Framework for K-12 Science Education* released by the National Research Council (NRC) in July 2011. While not a set of standards, the NRC states that the *Framework* includes "the key scientific practices,

[6] Chester E. Finn, Jr., foreword to *State Science Standards 1998*, by Lawrence S. Lerner (Washington, D.C.: Thomas B. Fordham Institute, March 1998), http://www.edexcellence.net/publications/stsciencestnds.html.

[7] Sheila Byrd Carmichael, Gabrielle Martino, Kathleen Porter-Magee, and W. Stephen Wilson, *The State of State Standards—and the Common Core—in 2010* (Washington, D.C.: Thomas B. Fordham Institute, July 2010), http://www.edexcellence.net/publications/the-state-of-state.html.

concepts, and ideas that all students should learn by the time they complete high school" and that it is "intended as a guide for those who develop science education standards, those who design curricula and assessments, and others who work in K-12 science education."[8]

In August 2011, we asked the distinguished biologist (and veteran Fordham science reviewer) Paul R. Gross to evaluate the NRC *Framework*. Overall, he gave it a solid B-plus, and found that the document includes nearly all of content necessary for a rigorous K-12 science curriculum.[9] Dr. Gross did caution, however, that the *Framework* may have paid too much attention to engineering and technology, as well as to "science process" skills. And he warned that standards writers using this framework as a model will need to make difficult decisions about priorities that were not made by the *Framework* authors.

When those "common" standards for science are ready, we at the Thomas B. Fordham Institute will review and evaluate them. But we also want to help states now—for today's students can't wait for common science standards, and today's states are using academic standards of their own as the basis for what their schools will teach and their children will learn.

Hence it's time for a fresh review of existing state science standards. While forty-nine states and the District of Columbia had articulated science standards when we examined them in 2005, Iowa subsequently wrote its own standards and forty-two states and the District of Columbia have changed their standards during the ensuing years.

Our Approach

This report is part of a comprehensive series of fresh appraisals by Fordham of state, national, and international standards in all core content areas. Here we provide analyses of the K-12 science standards currently in place in all fifty states and the District of Columbia, as well as the assessment framework that undergirds the NAEP science assessment. These reviews should also help states gauge the comparative strengths and weaknesses of their standards vis-à-vis the forthcoming Next Generation Science Standards—and how they stack up today against the science education expectations that undergird NAEP.

Why Review NAEP?

The National Assessment of Education Progress (NAEP) is the most-often used barometer of student learning in science. Results from NAEP are used to compare student achievement across states and to judge states' student-proficiency levels. Because NAEP is so central to the conversation on state and national science achievement, we felt it was important to analyze the quality of its implicit standards—embodied in its assessment framework—to see how they compare with the quality of each state's standards.

For these reviews, we have enlisted the help of several veteran reviewers, all of them experts in their field. Lawrence Lerner joined us as lead author for this evaluation of state science standards. Dr. Lerner has played a role in all of our science reviews, dating back to 1998. This time he is joined by a team of experts: Ursula Goodenough, who evaluated life science; Richard Schwartz, who primarily reviewed chemistry and physical science; Martha Schwartz, who analyzed earth and space science; and John Lynch, who evaluated "science inquiry" standards.

In addition, Dr. Gross rejoined us to appraise the NAEP assessment framework for science.

Our experts employed new and improved content-specific criteria as well as the "common grading metric" that has been used for all of the reports in this cycle of Fordham standards reviews.[10] Application of those criteria and the common metric yields—for every state in every subject—a two-part score: a tally from zero to seven for "content and rigor," and a tally from zero to three for "clarity and specificity." These were combined such that each set of standards obtained a total number grade (up to ten), which was then converted to a letter grade (from A through F). (For more detail, see Appendix A: Methods, Criteria, and Grading Metric.)

What We Found

The results of this rigorous analysis paint a fresh—but still bleak—picture. A majority of the states' standards remain mediocre to awful. In fact, the average grade across *all* states is—once again—a thoroughly undistinguished C. (In fact, it's a

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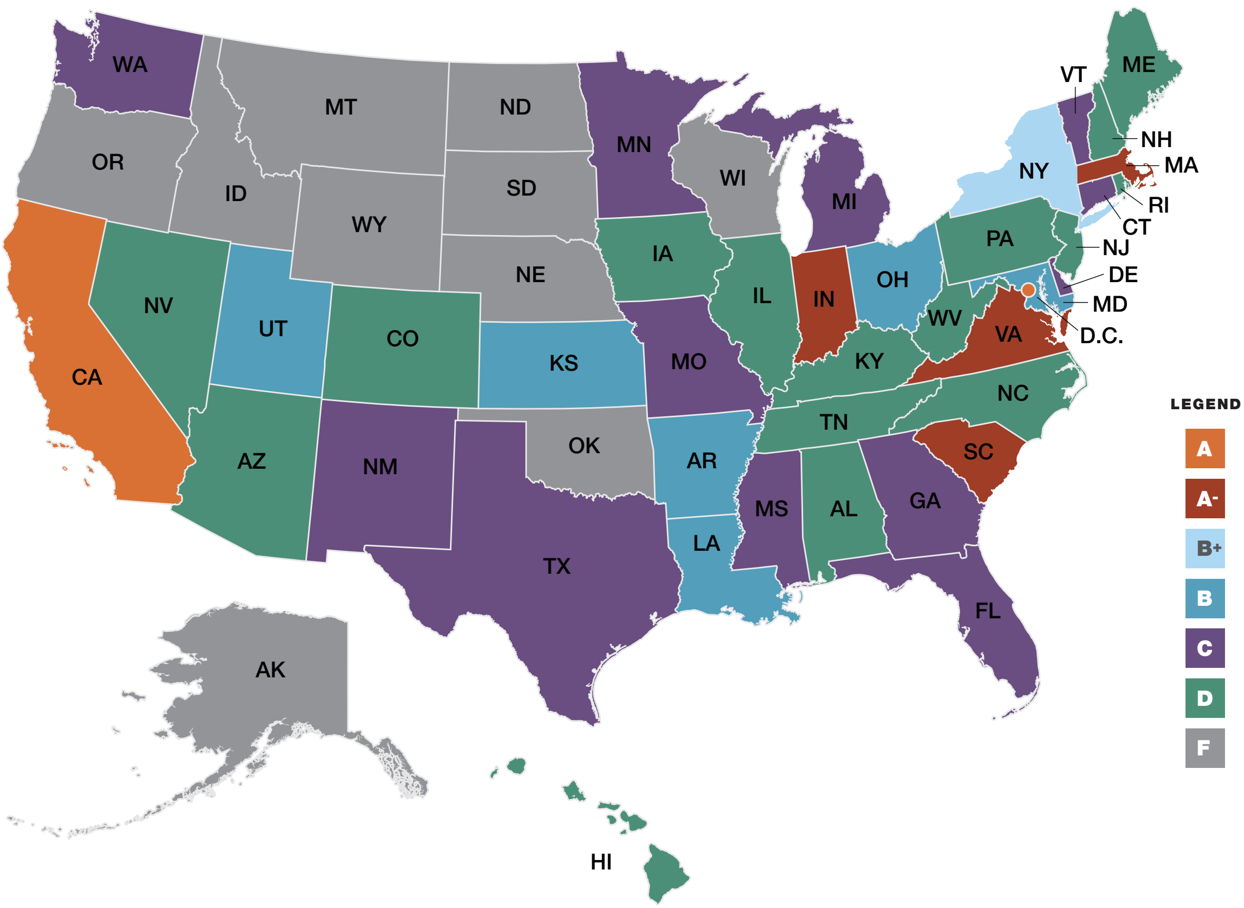
[8] National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (Washington, D.C.: National Research Council, July 2011), http://www.nap.edu/catalog.php?record_id=13165.

[9] Paul R. Gross, *Review of the National Research Council's Framework for K-12 Science Education* (Washington, D.C.: Thomas B. Fordham Institute, October 2011), http://www.edexcellence.net/publications/review-of-the-nrc-framework-for-k12-science-education.html.

[10] To read our 2010 review of state ELA and math standards and the Common Core, see http://www.edexcellence.net/publications/the-state-of-state.html. For our 2011 analysis of state U.S. History standards, see http://www.edexcellence.net/publications/the-state-of-state-us.html.

State Science Standards Grades, 2012



low C.) In twenty-six jurisdictions, the science standards earn a D or below. Yet this very weakness in what states expect of their schools, teachers, and students in science suggests that a purposeful focus on improving—or replacing—today's standards could be a key part of a comprehensive effort to boost science performance.

Two jurisdictions—California and the District of Columbia—have standards strong enough to earn straight As from our reviewers. Four other states—Indiana, Massachusetts, South Carolina, and Virginia—earn A-minuses, as does the NAEP assessment framework. And seven states earn grades in the B range. But this also means that just thirteen jurisdictions—barely 25 percent, and fewer than in 2005—earn a B or better for setting appropriately clear, rigorous, and specific standards.

Of course, as Dr. Lerner noted in 1998:

> **When it comes to academic standards…even a "B" ought not be deemed satisfactory. In a properly organized education system, standards drive everything else. If they are only "pretty good," then "pretty good" is the best the system is apt to produce by way of student learning. No state should be satisfied with such a result. Hence, no state should be satisfied with less than world-class standards in a core academic subject such as science.**

States looking to improve their standards, however, need not start from scratch, or even wait for the NGSS. They can look to places like California and the District of Columbia, and also to the NAEP assessment framework, for models of excellence.

Let us repeat that even the finest of standards alone will never yield outstanding academic achievement. Several states with exemplary science standards still aren't serious about setting high proficiency bars on their assessments. Others don't hold students (or their teachers) properly accountable for learning (or successfully imparting) important content. And still others haven't provided (or directed teachers to) the curricular and instructional resources that teachers need to drive achievement. But,

Table 1. 2005 and 2012 Grades in Alphabetical Order

Jurisdiction	2005 Grade	2012 Grade	Jurisdiction	2005 Grade	2012 Grade
Alabama	F	D	Montana	F	F
Alaska	F	F	Nebraska	F	F
Arizona	B	D	Nevada	D	D
Arkansas	D	B	New Hampshire	F	D
California	A	A	New Jersey	B	D
Colorado	B	D	New Mexico	A	C
Connecticut	C	C	New York	A	B+
Delaware	C	C	North Carolina	B	D
District of Columbia	C	A	North Dakota	D	F
Florida	F	C	Ohio	B	B
Georgia	B	C	Oklahoma	F	F
Hawaii	F	D	Oregon	F	F
Idaho	F	F	Pennsylvania	C	D
Illinois	B	D	Rhode Island	C	D
Indiana	A	A-	South Carolina	A	A-
Iowa	N/A	D	South Dakota	D	F
Kansas	F	B	Tennessee	B	D
Kentucky	D	D	Texas	F	C
Louisiana	B	B	Utah	C	B
Maine	D	D	Vermont	C	C
Maryland	B	B	Virginia	A	A-
Massachusetts	A	A-	Washington	C	C
Michigan	D	C	West Virginia	B	D
Minnesota	B	C	Wisconsin	F	F
Mississippi	F	C	Wyoming	F	F
Missouri	C	C			

while standards alone won't drive achievement, they are an important place to start.

Changes since 2005

Of the forty-four jurisdictions that have revised or replaced their science standards since our 2005 analysis, eleven have shown some improvement, and some of that improvement has been dramatic (see Table 1). Kansas, for example, moved from an F to a B and Arkansas moved from a D to a B. The District of Columbia rose from a mediocre C in our last analysis to a best-in-class A this time.

By contrast, sixteen states managed to make their standards *worse* since 2005. In fact, five of them—Colorado, New Jersey, North Carolina, Tennessee, and West Virginia—dropped from Bs to Ds.

On balance, the combination of improvements and worsenings had little impact on our national average. In both 2005 and 2012, the average grade for state science standards was a minimal C.[11]

[11] Note, however, that our criteria have changed since 2005. Therefore, changes in a state's grade could be due to changes in the quality of the standards, changes in our criteria, or both. For more information on our grading metric, see Appendix A.

Acknowledgments

Generous support for this project came from the Carnegie Corporation of New York, as well as from our sister organization, the Thomas B. Fordham Foundation.

We also thank the many individuals who made this endeavor possible. First and foremost, we are deeply grateful to our content-area experts and report authors, Lawrence Lerner, Richard Schwartz, Martha Schwartz, Ursula Goodenough, and John Lynch. We are also grateful to Lawrence Lerner and Adam Marcus for helping to cobble together the patchwork of reviews into a single, clean product. And once again, we thank Paul Gross, who helped shape the direction of the project and provided wisdom and guidance throughout, in addition to conducting the NAEP review.

At the Fordham end, special thanks goes first to Amber Winkler, Fordham's vice president for research, who provided ongoing guidance and support from the project's inception, and to Daniela Fairchild, who helped manage the project and steer it toward the finish line. We are also grateful to our team of interns—Alicia Goldberg, Josh Pierson, Laura Johnson, and Michael Ishimoto—for their help researching the standards, confirming standards documents, and reviewing the final report.

Special thanks go as well to the Fordham production team—Janie Scull, Joe Portnoy, and Tyson Eberhardt—for the work they did to ensure the final report was properly edited, published, and disseminated. We are grateful to Shannon Last and Alton Creative, not just for their expert copyediting and layout work (respectively), but also for their hard work and patience as we moved this report through production. Finally, we thank Sarah Samaroo for producing an epic cover illustration.