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re:VISION

A NEW FOUNDATION FOR SCIENCE EDUCATION
The Development of the Next Generation Science Standards

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Policymakers, business leaders, and the public understand the importance of science and mathematics education to keep the United States workforce strong and competitive. Americans are proud of our ability to innovate, develop new products, and solve problems.

It is also widely understood that U.S. students need more effective science education. In a recent survey, 97 percent of voters agreed that improving the quality of science education in our public schools is important to our country's ability to compete globally.[1]

Science education plays a critical role in developing a student's ability to analyze a situation, develop potential solutions, and evaluate the effectiveness of those solutions. These skills are key components of college and career readiness – for students who aim to enter careers in science and engineering, but also for students who pursue careers in other fields.

Science education also contributes to our nation's health and well-being, giving students the ability to navigate challenges in everyday life. We live in a world full of information that needs to be deciphered in order to make personal decisions, yet many of our high school, and even college graduates, are not prepared to understand or interpret basic guidelines or warnings. According to the last National Assessment of Adult Literacy, fewer than one in three college graduates can perform tasks such as interpreting a data table about blood pressure and physical activity.[2]

Yet despite the widely understood importance of science education, students in the U.S. have continued to flounder in science achievement on national and international assessments. For this reason, educators and scientists set out in 2010 to develop a set of standards that would form the basis of a more effective system of science education for students across the nation. These standards are based

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on research that has emerged in recent decades on how students best learn science, offering an evidence-based approach to teaching a subject area that is by nature always changing and becoming more complex.

The recent release of *Next Generation Science Standards (NGSS)* offers states a new foundation for science education. The standards, developed by a voluntary coalition of 26 states, were crafted with the input of scientists and engineers, educators, business leaders, higher-education faculty, and policy leaders. The resulting product of this massive undertaking is a notable improvement over the sets of standards developed by national professional organizations 15 years ago, which are quite outdated but still being used as the basis for state science standards across the country.

This brief is intended as an overview for policy leaders who need a concise summary of why and how the NGSS were developed, important ways in which they differ from current state standards, and considerations as they determine whether the NGSS will be adopted in their respective states.

CONTEXT

Science and mathematics education plays an essential role in the American workforce. Jobs in science, technology, engineering, and mathematics (STEM) drive the development of new products and technologies that bring dramatic changes to industry and personal living. These occupations are particularly concentrated in cutting-edge industries such as computer systems design, scientific research and development, and high-tech manufacturing industries. Most STEM occupations provide wages significantly above the U.S. average and require a bachelor's degree or higher.[3]

The demand for effective science education is not limited to STEM careers – all students need a strong understanding of science to keep their postsecondary training, education, and career options open. When the National Association of State Directors of Career Technical Education Consortium grouped all occupations into 16 career clusters, they found that 14 of the 16 career clusters call for four years of science education in high school, with the remaining two clusters calling for three years of science education.[4] Aside from job market expectations, American students also need the ability to understand and evaluate scientific data as they receive information about healthcare, computer technology, pandemics, energy shortages, and products and services they wish to purchase.

Unfortunately, test data indicate that **American students consistently fall short of a firm grounding in scientific understanding.** In international comparisons of science education, American students are outperformed by their peers in other countries. For example, in the 2011 Trends in International Mathematics and Science Study (TIMSS), which compares academic achievement across more than 60 countries, U.S. 8th graders ranked 13th in science.[5] The Program for International Student Assessment (PISA), an international assessment that includes evaluation of 15-year-olds' capabilities in science literacy and problem solving, ranked U.S. students 17th.[6] Should American students decide to pursue occupations in STEM fields, many will find that they simply are not prepared for postsecondary education or training in the sciences. In 2011, fewer than 1 in 3 students met ACT's College Readiness Benchmark in Science, meaning they had a 50 percent chance of obtaining a B or higher or a 75 percent chance of obtaining a C or higher in a first-year, credit-bearing biology course.[7]

In order to revamp science education in the U.S., states must first address the foundation of instruction—**an expansive and outdated set of K-12 content standards.** Most states have based their K-12 science standards on two documents developed by professional organizations: the National Research Council's *National Science Education Standards* (1996) and the American Association for the Advancement of Science's *Benchmarks for Science Literacy* (1993). These standards were developed by considering each subject area of science independently. As scientists advocated for specific content to be included within their respective disciplines, the standards came to include more material than any K–12 school system could teach well.[8] Also, having not been updated in 15 years, the standards do not account for the dramatic proliferation of technology and other major advances in science that have occurred since the mid-1990s.

Over the past two decades, researchers have developed a greater understanding about the way students learn scientific concepts. In response, a number of national reports and committees have called for changes in science education. In 2005, the National Research Council (NRC) published *America's Lab Report*, an examination of lab-based learning in American high schools that called for **better integration of science content with hands-on learning experiences.** In *Taking Science to School*, a notable 2007 report focused on K-8 science education, the NRC reviewed the research on children's development of scientific knowledge and recommended ways in which schools should respond. The report noted that current standards fail to reflect what is known about children's thinking and need to be rebuilt to **focus on core scientific ideas**.[9]

By 2010, the science education community was eager to build upon this growing base of knowledge. As the Common Core State Standards for English language arts and mathematics were released and being widely adopted across the country, states began to request a collective effort to establish a contemporary set of standards for science education. In response, the *Next Generation Science Standards* initiative was born.

Resources for Further Investigation

A FRAMEWORK FOR K-12 SCIENCE EDUCATION: PRACTICES, CROSSCUTTING CONCEPTS AND CORE IDEAS

Learn more about the framework that formed the basis for the Next Generation Science Standards.

www.nap.edu/catalog.php?record_id=13165

THE NEXT GENERSTION SCIENCE STANDARDS

Explore the standards and learn about the activities of lead state partners as they undertake implementation.

www.nextgenscience.org/

THE NEXT GENERATION SCIENCE STANDARDS (NGSS)

Before a new set of K-12 science standards could be developed, agreement was needed on the foundational knowledge and skills students should acquire by the end of high school.

In fall 2011, the Carnegie Corporation of New York awarded a grant to Achieve to coordinate the development of the new standards.

Step 1: Agreement on scientific concepts to be taught in K-12

Science content is ever-changing, and much of what is known today is the result of an explosion of knowledge and discovery that has occurred in the past 50 years. It would be impossible to include all relevant content in a set of concise, coherent science standards. Therefore, tough decisions and careful structuring were needed to form a framework for standards developers to follow.

To establish such agreement, the NRC convened a committee of Nobel Laureates, practicing scientists and engineers, cognitive scientists, and science education experts. The Committee on a Conceptual Framework for New K-12 Science Education Standards focused on two aspects of science education: 1) how to educate *all* students in science and engineering, and 2) identifying knowledge that is foundational for *those who will later become scientists and engineers*. Among the Framework's stated goals were ensuring that students are equipped to become careful consumers of scientific and technological information related to everyday life and would develop the skills to enter their career of choice, including, but not limited to, careers in science, engineering, and technology.

To build upon the current research base and establish a platform for more effective science education in the U.S., the NRC's Framework was designed to

- organize learning systematically across multiple years of schooling, rather than having students study distinct subjects each year;
- emphasize depth over breadth by focusing on a limited number of core ideas and concepts that apply across various science disciplines ("crosscutting concepts"); and
- provide students with engaging opportunities to experience how science is actually done.

The Framework describes the content and sequence of learning expected of K-12 students, but not in such detail as grade-by-grade standards. Rather, the Framework provides a more general guide for those who develop standards, curriculum, assessments, teacher-preparation programs, and professional development for current educators.[10]

Step 2: Development of the Standards

Achieve is an independent, bipartisan, nonprofit education reform organization that helps states raise academic standards and graduation requirements, improve assessments, and strengthen accountability. Achieve was well positioned to facilitate a collective state-led effort, having worked intensively with states since 2005 to raise and improve K-12 standards through the *American Diploma Project*. Achieve's charge was to design a standards development process that would take state and expert input into account while adhering to the recommendations of the NRC Framework.

Twenty-six states volunteered to work with Achieve to develop the NGSS. These lead states selected an array of K-12 educators and administrators, higher education faculty, scientists and engineers, business leaders, policymakers, and other key organizations with a wide range of views and perspectives to undertake the standards drafting process. Each participating state also established its own broad-based review team to engage additional educators, business leaders, and community members in the process. Finally, feedback from the public was actively sought and incorporated; there were two public review periods during which stakeholders responded with thousands of comments.

The NGSS were benchmarked against countries whose students perform well on the international TIMSS and PISA assessments, including Finland, South Korea, China, Canada, England, Hungary, Ireland, Japan, and Singapore. The standards also respond to research on student learning by actively engaging students, applying cross-cutting concepts to form deep understanding of core ideas, and connecting scientific principles to real-world situations. One notable difference between the NGSS and former U.S. science standards is the integration of engineering and technology into the structure of science education. The NGSS further aid the integration of science with other subject areas by making explicit connections to the Common Core State Standards for English language arts and mathematics (an appendix will be made available soon). The standards are also being developed in an electronic format that allows educators to explore connections between core scientific concepts and skills and other subject areas.

After the lead states released draft versions of the standards for public review and considered more than 10,000 comments from each release, the final standards were unveiled in April 2013. They have attracted attention from those who wish to improve science education dramatically within their respective states. The extensive involvement of science educators may help to quell concerns about the shifts in instruction that will be required to help students achieve the NGSS. For example, at a recent convening of the National Science Teachers Association, roughly 90 percent of the meeting participants indicated that they had been involved in the NGSS development process as writers, state representatives and members of the critical stakeholders group or had provided feedback on one of the publicly released drafts.[11]

Public Support for the New Science Standards

87 PERCENT OF VOTERS SURVEYED INDICATED THAT THEY ARE SUPPORTIVE OF A COLLECTIVE STATE EFFORT TO DEVELOP NEW STANDARDS THAT ARE INTERNATIONALLY-BENCHMARKED, MORE CHALLENGING AND WILL REQUIRE STUDENTS TO APPLY THEIR SCIENCE KNOWLEDGE AND UNDERSTAND HOW SCIENCE CONCEPTS FIT TOGETHER.

Source: Achieve, March 30, 2012

CONSIDERATIONS FOR STATE POLICY LEADERS

As policy leaders learn about the NGSS and determine whether it makes sense for their own state to adopt the standards, the following considerations need to be taken into account:

WHAT IS MY STATE'S TIMELINE FOR REVISING OUR K-12 SCIENCE STANDARDS?

Most states schedule revisions to their K-12 education standards every several years. For some states, the release of the NGSS occurred as their standards revision process was emerging or getting underway. For other states, the next round of revision might be just a few years away.

WOULD NGSS ADOPTION CONFLICT WITH OTHER REFORMS NOW UNDERWAY?

Many states are currently wrestling with major instructional shifts as they begin implementation of college and career-ready standards in English language arts and mathematics. States across the nation are also implementing new teacher evaluation systems and preparing to implement online assessment systems. In reviewing the reforms that are underway, state policy leaders need to determine whether NGSS adoption and implementation would complement current efforts or if the addition of another reform could have negative repercussions. In some cases, both are true, and trade-offs will need to be considered. For example, if a state is about to take on a major initiative to modernize teacher preparation programs, it would make sense to align the programs with science standards that reflect the latest research.

HOW WILL STAKEHOLDERS IN MY STATE RESPOND TO THE MORE CHALLENGING ELEMENTS OF NGSS?

The NGSS are based on the scientific community's strong agreement about what constitutes solid science. This includes a few scientific topics that still attract debate in some parts of the country including climate change and evolution. NGSS leaders have encouraged states to be cautious about the political conditions in their states and not push for adoption or implementation before the time is right.

WHAT CHANGES WILL BE NEEDED IN DISTRICT CAPACITY, RESOURCES, AND TEACHER TRAINING?

Adoption of new content standards is merely the first step toward more effective science education for students. As state leaders consider whether and when to adopt the NGSS, it is essential that they simultaneously consider the steps needed to put the standards into effect. By inquiring about and considering potential obstacles and resources to build upon, policymakers are better able to establish a clear and thoughtful plan for adoption and implementation.

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The 16 career clusters include Agriculture; Architecture & Construction; Arts, A/V Technology & Communication; Business; Education; Finance; Government; Health Science; Hospitality & Tourism; Human Services; Information wTechnology; Law, Public Safety; Manufacturing; Marketing, Sales, Service; Science, Technology, Engineering & Mathematics; and Transportation.

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11 As noted by Stephen Pruitt via phone on April 17, 2013.

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