



Next Generation Science Standards: Considerations for Curricula, Assessments, Preparation, and Implementation

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Recent debates over the Common Core State Standards (CCSS) have brought national attention to the issue of standards in schools. While more than 40 states and territories work to implement the CCSS, others are reconsidering and reviewing their standards. The work that policymakers carry out with regard to standards, however, is not limited to English language arts and mathematics—the two subjects addressed by the CCSS. Instead, education policymakers consider standards for all subjects, and many are currently studying standards in science.

Many states' science standards are based on guidance documents created by the National Research Council in 1996 that do not reflect the scientific advances and educational research findings that have since occurred. Among options for policymakers to consider to update existing standards are the Next Generation Science Standards (NGSS), a set of standards released in April 2013 that articulate expectations for student performance in science in grades K–12. Although states can adopt the NGSS outright without modifications, they may also use them to guide the creation of their own science standards. As of September 2014, 12 states and the District of Columbia have officially adopted the NGSS, and the standards are under consideration in various other states and districts.

This brief provides an overview of the NGSS, discusses issues for policymakers to consider with regard to those standards, and presents examples from states considering or implementing the NGSS. Questions to consider and recommendations appear at the end of the document.

What are the Next Generation Science Standards?

The Next Generation Science Standards establish performance expectations for K–12 students across science disciplines and, for the first time, include standards for engineering. They are a product of a three-year process to update existing National Standards for Science Education (National Research Council [NRC], 1996) resources that involved a variety of stakeholders, including the National Research Council (NRC), the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS), a network of 26 “lead states,” and Achieve, a nonprofit education organization that also supported CCSS development.

The NRC began the process in 2010 by convening prominent scientists and engineers, policy experts, and science education researchers to develop *A Framework for K–12 Science Education*, which draws on current research to describe the science that K–12 students should know. Then, in a process coordinated by Achieve, 26 states volunteered to serve as “lead states” in the development of the NGSS. Forty-one writers from these states—experts in science, engineering, state standards, workforce development, and students with disabilities—used the NRC's Framework as the basis for new standards. NSTA and AAAS served as advisors throughout the process and also worked to solicit feedback from the science education and scientific communities. After multiple drafts and reviews by scientists, education experts, business leaders, and the public, the NGSS were released in April 2013 (Achieve, Inc., 2014).¹

¹ The lead state partners include AZ, AR, CA, DE, GA, IL, IA, KS, KY, ME, MD, MA, MI, MN, MT, NJ, NY, NC, OH, OR, RI, SD, TN, VT, WA, and WV. For a detailed description of the process used to develop the NGSS, see Achieve, Inc. (2014). “Development Process.” Retrieved from www.nextgenscience.org/development-process

Each NGSS standard contains three elements:

- Disciplinary core ideas, which are grouped into the earth and space sciences; the life sciences; the physical sciences; and engineering, technology, and applications of science
- Science and engineering practices, which include the practices that scientists and engineers use as they build models, develop theories, and create systems
- Crosscutting concepts, which apply across science disciplines and include patterns; cause and effect; systems and system models; energy and matter in systems; structure and function; stability and change of systems; and scale, proportion, and quantity (National Research Council, 2012; NGSS Lead States, 2013)

The integration of each of these elements into every standard represents a shift from traditional practice, which frequently divides these three elements across standards (National Association of State Boards of Education [NASBE], 2013; NGSS Lead States, 2013). According to NGSS authors, this shift was part of an intentional effort to more accurately reflect the ways in which real scientists and engineers carry out their work (NGSS Lead States, 2013).

The authors of the NGSS also designed the standards to emphasize deeper understanding and practice with content. Under the NGSS, students study fewer disciplines than they have under other standards, but their work involves developing a more complex understanding of scientific concepts by practicing and applying those concepts (Henderson, 2013). While previous standards described knowledge that students should possess, the NGSS describe what students must do to demonstrate their knowledge. For instance, rather than requiring that students “know” or “understand” a concept, the NGSS ask students to “argue,” “model,” “explain,” and “analyze” to demonstrate that they have reached an expected competency.

NGSS authors also worked to ensure that concepts build logically into learning progressions from grades K–12 and that the NGSS are aligned with the CCSS (NASBE, 2013; NGSS Lead States, 2013).

Ultimately, the authors of the NGSS designed the standards to build student capacity “to acquire and apply scientific knowledge to unique situations and to think and reason scientifically” (NGSS Lead States, 2013, p. xvi).

Implementation Considerations

As efforts to implement the Common Core and other standards have shown, changing or updating standards is a complex process that requires significant investments of time, money, and human resources. As such, states, districts, and schools reviewing or implementing the NGSS have much to consider:

Curriculum and Instructional Materials. The NGSS define what K–12 students are expected to know and be able to do in science. They do not include curricula or instructional materials. Policymakers considering the NGSS, then, may wish to create a plan for developing NGSS-aligned curricula and instructional materials.

NRC’s *Framework* includes guidance on developing curricula and instructional materials that may be useful to policymakers. Their recommendations include developing curricula that

- successfully integrate the three elements of the NGSS;
- encourage students to move toward growing complexity in their thinking over the years; and
- help teachers understand how to cultivate student ability to produce models and explanations and engage in scientific practice (NRC, 2012).

Assessments. The NGSS establish the competencies that students are expected to demonstrate, but they do not establish how to assess those competencies. As such, policymakers may wish to review current science assessments in the states or districts they represent and determine how new NGSS-aligned assessments might be developed. The following information may help policymakers as they consider assessment development:

- Assessments may be diagnostic, formative, summative, formal, informal, designed to inform classroom instruction, and designed to inform decision making on school, district, and state levels. The NRC recommends that NGSS-aligned assessments begin with classroom-level instruction and assessment and move toward larger-scale assessments used for monitoring and accountability purposes (NRC, 2014). Providing for multiple, various forms of assessment—ranging from standardized tests to student portfolios—helps students accurately demonstrate their competencies (NRC, 2014).

- Teachers will need support when developing “three-dimensional” classroom-based assessments that align with the vision of science learning outlined in the NRC’s *Framework* (NRC, 2014).
- Accounting for student performance across the NGSS’ three elements will likely require developing complex means of assessing student learning. To gauge the depth of learning, assessment tasks may ask students to perform hand-on activities, engage with science simulations, create artifacts, develop models, provide explanations, and answer sets of related, complex questions (NRC, 2014; Pellegrino, 2013). Developing such complex assessments is likely to be time- and resource-intensive.
- In developing assessments, states and others can cut costs by joining consortia; such arrangements are particularly cost-effective for smaller states (Pecheone, Kahl, Hamma, & Jaquith, 2010).
- Assessments will need to be selective as the NGSS contain more performance expectations per grade level than can be assessed in a single testing session (NRC, 2014).
- Successful assessments do not use biased language and fairly measure the skills and knowledge of students from diverse backgrounds (Darling-Hammond, et al., 2013).

Capacity Building for Educators. In many schools, the adoption of the NGSS marks a major shift from previous practice, and many educators will need to develop new competencies. Providing educators with the support necessary to develop these competencies will increase the likelihood of successful implementation.

Policymakers considering the NGSS may wish to review current science educator preparation programs, professional learning opportunities, and mentoring programs to determine how these opportunities may be leveraged to ensure that educators receive appropriate training. According to the NRC, preparation programs and professional learning opportunities aimed at building capacity in the NGSS will likely need to support teachers with the following:

- Building the capacity to incorporate disciplinary core ideas, scientific and engineering practices, and crosscutting concepts into single lessons
- Deepening understanding of pedagogical content relevant to science
- Understanding how scientists work together, specifically with regard to how teams produce new explanations, theories, and models
- Building capacity to use student models, classroom discussion, and other strategies to inform formative assessment (NRC, 2012)

Instructional Time. Survey data show wide variation in the amount of instructional time devoted to science in U.S. public schools (Banilower, et al., 2013). One of the major shifts in the NGSS is an increased emphasis on scientific and engineering practices—a change that will likely require allotting more in-class laboratory time to students (Schachter, 2013). As such, those considering NGSS implementation may wish to investigate how much class time teachers in their state or district devote to science instruction and whether successful transition to the NGSS will require increases in time for science instruction.

Timing. NGSS implementation will likely require managing significant changes at classroom, school, district, and state levels. Those adopting the NGSS will need to carefully develop an implementation schedule. States currently working to implement the NGSS have designed varying schedules, ranging from those that begin implementation in the fall of 2014, to those that schedule full implementation in the fall of 2017. In developing an implementation plan, decision makers may wish to consider including the following: stakeholder engagement and awareness-raising, curriculum and instructional materials design, the development of and transition to new assessments, changes to educator preparation and professional learning programs, the phasing in of standards by grade level, and other necessary adjustments to policies (Achieve & U.S. Education Delivery Institute, 2013).

Additional Standards and Curriculum. The authors of the NGSS intended to design a set of standards that would describe what all students should know and be able to do in science. Such a system does not necessarily account for all science instruction. Policymakers considering the NGSS may wish to consider additional science standards and curricula, particularly when additional standards and curricula would enhance advanced offerings for students interested in STEM careers or contextualize science within the region.

Other Considerations. Given the extent of work involved in updating and implementing new standards in any subject, policymakers considering the NGSS will have many other issues to study, including the following:

- Approaches to conducting a science education needs assessment to determine the condition of science education in a given state or district
- Strategies for engaging stakeholders, including students and their families, in the standards adoption or adaptation process
- Options for arranging NGSS performance expectations into courses (the NGSS provide performance expectations by grade in levels K–5 but provide grade-banded expectations for middle and high school)
- Possible changes to graduation requirements, exit exams, and course credit requirements
- The alignment of the NGSS to standards in other subjects
- Strategies for ensuring that new science standards, instructional practices, and assessments address achievement gaps in science and provide equal opportunities to students from diverse backgrounds
- Strategies for ensuring that the standards are used to advance student and family understanding and ownership of student educational progress
- Approaches to evaluating the success of standards implementation

Next Generation Science Standards in the States

As of September 2014, the District of Columbia and the following 12 states have adopted the NGSS: California, Delaware, Illinois, Kansas, Kentucky, Maryland, Nevada, New Jersey, Oregon, Rhode Island, Vermont, and Washington. While these states work to initiate NGSS implementation, others, including school districts, are reviewing the NGSS to determine if they are appropriate for schools in their region. The examples below represent a range of positions that states have taken on the NGSS:

Kentucky served as a lead state in the development of the NGSS, and the Kentucky Board of Education approved the adoption of the standards in June 2013. Implementation began in fall 2014, when Kentucky teachers adjusted curriculum and teaching based on the NGSS. The Kentucky Department of Education (KDOE) has not yet developed assessments based on the NGSS and will not require student testing in science during the 2014–15 academic year. Science testing will continue once NGSS-aligned assessments have been completed (Kentucky Department of Education [KDOE], June 2014; KDOE, May 2014).

The **Maryland** State Board of Education voted to adopt the NGSS in June 2013 after the state served as a lead state in the creation of those standards. The Board and the Maryland State Department of Education (MSDE) also established a vision statement for the Maryland NGSS, a team to oversee implementation, an evaluation tool to gauge the success of implementation, a plan to engage stakeholders and form partnerships, and a timeline that schedules full implementation for 2017–2018 (Eberle, 2014). Prior to full implementation, MSDE plans to create NGSS-aligned preK–12 course guidelines, investigate high school science course sequences, produce NGSS-aligned instructional models, and provide technical assistance to local education agencies (Eberle, 2014).

The **Massachusetts** Department of Elementary and Secondary Education (ESE) is working toward the adoption of revised science and technology/engineering standards (Massachusetts Department of Elementary and Secondary Education [ESE], May 2014). Although Massachusetts served as a lead state in NGSS development, it adapted the NGSS based on public input rather than adopt the NGSS outright. The following represent some of the differences between the NGSS and Massachusetts' revised standards: Massachusetts' standards omit crosscutting concepts, including only disciplinary core ideas and science and engineering practices; include performance expectations specific to each middle school grade rather than treating middle school as a grade band; and present technology and engineering as a discipline rather than an application of science (ESE, January 2014). The state's revised science standards also respond to public feedback suggesting that the NGSS standards are too broad, allowing for inconsistent interpretation, and that the NGSS standards do not adequately define college and career readiness (ESE, January 2014). Districts and schools may use Massachusetts' revised science standards as ESE accepts further public input (ESE, May 2014). Formal adoption is scheduled for the 2015–2016 school year, after which ESE plans to release an implementation timeline (ESE, May 2014).

Nevada did not serve as a lead state in the development of the NGSS but did use the NGSS as the basis for its 2014 Nevada State Academic Content Standards for Science. According to the Nevada Department of Education (NDOE), district implementation of the standards is scheduled for the 2014–15 school year (Nevada Department of Education [NDOE], 2014). NDOE has asked that district implementation teams and science education stakeholders collaborate via the Next Generation Science Education Network to discuss next steps for implementing Nevada's new NGSS-based science standards (NDOE, 2014).

Wyoming’s current state science standards were adopted in 2008 (Wyoming Department of Education [WDOE], 2014). The state did not serve as a lead state in designing the NGSS and has not adopted those standards. In March 2014, the governor signed a budget prohibiting the Wyoming State Board of Education from spending money to review or adopt the NGSS after some lawmakers objected to NGSS presentation of climate science (Todd, March 2014). In July 2014, the State Board resolved to cease work on science standards until the prohibition on reviewing the NGSS is retracted (Graff, 2014). Although state-level science standards review work has ceased, some Wyoming districts have adopted NGSS-aligned curriculum (Todd, June 2014).

Policy Issue	Questions to Consider
Developing Curricula and Assessments	<ol style="list-style-type: none"> 1. Where is my state or district with respect to the condition of science education and the adoption of the NGSS? 2. What science curricula do schools in my state or district currently use? Under current conditions, could these be changed to align with the NGSS? 3. How are current science standards in my state or district organized into grades? Can current courses in middle and high school accommodate the NGSS grade-banded performance expectations? 4. Would my state or district benefit from additional science curricula and coursework that reach beyond the NGSS, such as advanced or context-specific curricula? 5. How might my state or district ensure that new science curricula, instructional practices, and assessments address achievement gaps in science and provide equal opportunities to students from diverse backgrounds? What strategies for engaging diverse students have been successful in my state or district in the past? 6. What science assessments do schools in my state or district currently use? Do educators use diagnostic, formative, and summative assessments? 7. What resources are available for the development of new, more complex, three-dimensional science assessments? Would my state or district benefit from participating in a consortium to develop NGSS-aligned assessments?
Preparing Educators for the NGSS	<ol style="list-style-type: none"> 1. How do educators in my state or district currently teach science? What skills, abilities, and knowledge do they already bring to the science classroom? How might their abilities be enriched to provide NGSS-aligned instruction? 2. What professional development, mentoring, and educator preparation programs in science are currently available to educators in my state or district? How can these be enhanced to account for the NGSS? 3. How much time do educators in my state or district currently devote to science instruction? Will they need more instructional time for science to successfully transition to the NGSS?
Preparing Students and Families for the NGSS	<ol style="list-style-type: none"> 1. What mechanisms are available in my state or district to communicate with students and their families regarding the NGSS? What strategies can schools use to help students and families understand the NGSS and their own education data? 2. What role can businesses, networks, and other organizations in my state or district play in sharing information on the NGSS with community members? 3. What strategies for conveying information regarding the NGSS are most appropriate for my state or district? Would the NGSS be differentiated from or connected to efforts to communicate information about CCSS and other standards?
Planning NGSS Implementation	<ol style="list-style-type: none"> 1. Are educators and officials in my state or district prepared to transition to new science standards? Are other reforms scheduled that might interfere with NGSS implementation? If so, how can NGSS implementation be scheduled to ensure that educators and other officials can successfully manage the transition? 2. How much time will my state or district need for stakeholder engagement, curriculum and instructional materials design, the development or adoption of assessments, and changes to educator preparation and professional learning programs? 3. What strategy is best for phasing in NGSS standards in my state or district? Will my state or district best be served by instituting new standards across all grades in one year? Or by a more staggered or gradual approach? 4. What policies does my state or district currently have with respect to advanced coursework, graduation requirements, exit exams, and course credit requirements related to science education? Will these need to change before full NGSS implementation can occur? 5. How and when can my state or district evaluate progress toward NGSS implementation? Does my state or district currently have an evaluation protocol to address science standards and curricula? What approaches to evaluation have been successful in the past?

Recommendations

The Next Generation Science Standards represent a collaborative effort to update existing science standards based on the latest research. Given NGSS emphasis on deeper understanding, scientific and engineering practices, and scientific reasoning, transitioning to the NGSS is likely to be a significant change for many educators. Policymakers considering the NGSS will need to plan accordingly. The following recommendations may assist policymakers as they consider NGSS adoption, adaptation, or implementation:

- Investigate current science curricula, instructional materials, and courses in your state or district to determine how available resources will need to change to accommodate the NGSS.
- Consider whether additional standards and curricula, such as those that are advanced or context-specific, would enhance science education in your state or district.
- Review current science assessment practices in your state or district and evaluate options for developing NGSS-aligned assessments.
- Compile information on professional learning and educator preparation programs in science and determine how current opportunities may be leveraged to prepare educators for the NGSS.
- Examine policies and practices related to instructional time in science to determine whether current practices provide sufficient classroom time for NGSS implementation.
- Determine whether current avenues for communicating with students and their families allow for successful NGSS implementation and consider strategies for promoting community member engagement with the standards.
- Gather information to determine a tentative schedule for engaging stakeholders, developing NGSS-aligned curricula and assessments, revising professional learning programs, and making other necessary policy changes to enable NGSS implementation.
- Identify current protocol related to the evaluation of science standards and curricula in your state or district and consider options for developing evaluation protocol related to the NGSS.

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