2015 | Abridged Science Framework

NATIONAL ASSESSMENT GOVERNING BOARD

Introduction

In the rapidly changing world of the 21st century, science literacy is an essential goal for all of our nation's youth. Through science education, children come to understand the world in which they live and learn to apply scientific principles in many facets of their lives. In addition, our country has an obligation to provide young people who choose to pursue careers in science and technology with a strong foundation for their postsecondary study and work experience. The nation's future depends on scientifically literate citizens who can participate as informed members of society and as a highly skilled scientific workforce, well prepared to address challenging issues at the local, national, and global levels. Recent studies, including national and international assessments, indicate that our schools still do not adequately educate all students in science.

Grades 4, 8, and 12 student assessment

The National Assessment of Educational Progress (NAEP) and its reports are a key measure in informing the nation on how well the goal of scientific literacy for all students is being met. The science framework for the 2015 National Assessment of Educational Progress, the ongoing nationwide indicator of what fourth, eighth, and 12th grade students know and can do, sets forth the design of *The NAEP Science Assessment.*

Beginning in 2009, a new framework to guide the science assessment was necessary for several reasons: publication of *National Science Education Standards* and *Benchmarks for Science Literacy,* advances in both science and cognitive research, growth in comparing national and international science assessments, and increases in innovative assessment approaches. The framework reflects the nature and practice of science and represents a unique opportunity to build on developments in science standards, assessments, and research. In addition, the framework presents the content to be assessed as well as the conceptual base for the assessment.

At grades 4, 8, and 12, student assessment time is divided evenly between selected-response questions and constructed-response questions. At grade 4, the questions are distributed approximately evenly among physical science, life science, and earth and space sciences. At grade 8, there is a somewhat greater emphasis on earth and space sciences. At grade 12, the balance shifts toward physical science and life science, with less emphasis on earth and space sciences. From grade 4 to 8 to 12, the emphasis on using science principles increases and the emphasis on identifying science principles decreases. As students progress through the grades, it is expected that their analytical skills will increase. The science assessment measures achievement on national, regional, state, and subgroup levels, but it is not designed to report the performance of individual students or schools. NAEP results help educators, policymakers, and the public understand strengths and weaknesses in student performance and make informed decisions about education.

To further probe students' abilities to combine their understanding with the investigative skills that reflect practices, a subset of the students complete hands-on performance tasks or interactive computer tasks. Extra assessment time was provided for a portion of the student sample so that hands-on performance tasks and interactive computer tasks could be administered. Results of these tasks were released in a separate report.

The framework is the result of extraordinary effort and commitment by hundreds of individuals across the country, including some of the nation's leading scientists, science educators, policymakers, and assessment experts. Outreach activities gathered external feedback on the content statements from a variety of stakeholders: teachers, school and district administrators, state science education personnel, policymakers, and members of the business, industry, and postsecondary education communities.

NAEP Science Assessment

Science comprises both content and practices. NAEP addresses scientific knowledge and processes and assesses students' abilities to identify and use science principles, as well as use scientific inquiry and technological design. Although the framework distinguishes content from practice, the two are closely linked in assessment as in science.

SCIENCE CONTENT

The science content for NAEP is defined by a series of statements that describe key facts, concepts, principles, laws, and theories in three broad areas:

- Physical science
- Life science
- Earth and space sciences

Physical science deals with matter, energy, and motion; life science deals with structures and functions of living systems and changes in living systems; and earth and space sciences deal with Earth in space and time, Earth structures, and Earth systems.

SCIENCE PRACTICES

The framework is defined by four science practices: identifying science principles, using science principles, using scientific inquiry, and using technological design.

Identifying Science Principles.

This practice focuses on students' ability to recall, define, relate, and represent basic science principles specified in physical science, life science, and earth and space sciences content statements. Content statements often are closely related to one another conceptually. NAEP assesses a student's ability to describe, measure, or classify observations; state or recognize principles included in the content statements; connect closely related content statements; and relate different representations of science knowledge.

Identifying science principles comprises general types of observations, including describing, measuring or classifying observations; stating or recognizing correct science principles; demonstrating relationships among closely related science principles; and demonstrating relationships among different representations of principles.

Using Science Principles.

Scientific knowledge is useful for making sense of the natural world. Both scientists and informed citizens can use patterns in observations and theoretical models to predict and explain observations that they make now or that they will make in the future.

Using science principles comprises the following general types of performance expectations:

- Explain observations of phenomena (using science principles from the content statements).
- Predict observations of phenomena (using science principles from the content statements, including quantitative predictions based on science

principles that specify quantitative relationships among variables).

- Suggest examples of observations that illustrate a science principle. For example, provide examples of observations explained by the movement of tectonic plates.
- Propose, analyze, and/or evaluate alternative explanations or predictions.

Using Scientific Inquiry.

Scientific inquiry is a complex and time-intensive process that is iterative rather than linear. Scientists are expected to exhibit the habits of mind—curiosity, openness to new ideas, informed skepticism—that are part of science literacy. This includes reading or listening critically to assertions in the media, deciding what evidence to pay attention to and what to dismiss, and distinguishing

careful arguments from shoddy ones. These critical thinking and systems thinking skills are the basis for exercising sound reasoning, making complex choices, and understanding the interconnections among systems. Using scientific inquiry draws heavily on "knowing how," such as knowing how to determine the mass of an object.

In *The NAEP Science Assessment*, when students use scientific inquiry they are drawing on their understanding about the nature of science, including the following ideas:

- Arguments are flawed when fact and opinion are intermingled, or the conclusions do not follow logically from the evidence presented.
- If more than one variable changes at the same time as an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables.

Using Technological Design.

In both the *National Science Education Standards* and *Benchmarks for Science Literacy*, the term "technological design" refers to the process that underlies the development of all technologies, from paper clips to space stations.

As in scientific inquiry, the professional practice of technological design (also called engineering design) is complex and time intensive. Because NAEP addresses the subject area of science, the use of technological design components in *The NAEP Science Assessment* is limited to those that reveal students' abilities to apply science principles in the context of technological design.

Students' abilities to identify and use science principles should provide the opportunities as well as the limits for assessment tasks related to using technological design. For example, if students are asked to design a town's energy plan, they may be expected to consider the environmental effects of using natural gas versus using coal, but they would not be expected to consider the economic, political, or social ramifications of such a plan.

Using technological design comprises the following general types of performance expectations, all of which involve students using science knowledge to accomplish the following:

- Propose or critique solutions to problems, given criteria and scientific constraints.
- Identify scientific trade-offs in design decisions and choose among alternative solutions.
- Apply science principles or data to anticipate effects of technological design decisions.

Content and Design of the NAEP Science Assessment

The NAEP Science Assessment includes items sampled from the domain of science achievement identified by the intersection of the content areas and science practices at grades 4, 8, and 12. The assessments include selected-response (multiple-choice) questions and constructed-response questions (which include short and extended constructed-response).

At grade 4, the items are distributed approximately evenly among physical science, life science, and earth and space sciences. At grade 8, there is a somewhat greater emphasis on earth and space sciences. At grade 12, the balance shifts toward physical science and life science, with less emphasis on earth and space sciences.

The distribution of items across the science practices will be approximately 60 percent combining identifying science principles and using science principles, 30 percent using scientific inquiry, and 10 percent using technological design. From grade 4 to 8 to 12, the emphasis on using science principles increases and the emphasis on identifying science principles decreases.

At each of grades 4, 8, and 12, student assessment time is divided evenly between selected-response items and constructed-response items. Extra assessment time is provided for a portion of the student sample so that hands-on performance tasks and interactive computer tasks can be administered. In hands-on performance tasks, students manipulate selected physical objects and try to solve a scientific problem involving the objects. NAEP hands-on performance tasks provide students with a concrete task (problem) along with equipment and materials. Students are given the opportunity to determine scientifically justifiable procedures for arriving at a solution. Students' scores are based on both the solution and the procedures created for carrying out the investigation.

There are several types of interactive computer tasks. Information search and analysis items pose a scientific problem and ask students to query an information database and analyze relevant data to address the problem. Simulation items model systems (e.g., food webs) and ask students to manipulate variables and predict and explain resulting changes in the system. Empirical investigation items place hands-on performance tasks on the computer and invite students to design and conduct a study to draw conclusions about a problem. Results of the hands-on tasks and interactive computer tasks were released in a separate report.

Achievement Levels

NAEP specifies the science knowledge and skills necessary to achieve at *Basic*, *Proficient*, and *Advanced* levels for fourth, eighth, and 12th graders in each of the sciences and science practices.

Grade 4

For fourth grade, students performing at the *Basic* level should be able to describe, measure, and classify familiar objects in the world around them, as well as explain and make predictions about familiar processes. These processes include changes of states of matter, movements of objects, basic needs and life cycles of plants and animals, changes in shadows during the day, and changes in weather. They should be able to critique simple observational studies, communicate observations and basic measurements of familiar systems and processes, and look for patterns in their observations. With regard to scientific constraints, they should also be able to propose and critique alternative solutions to problems involving familiar systems and processes.

Students performing at the *Proficient* level should be able to demonstrate relationships among closely related science concepts, as well as analyze alternative explanations or predictions. They should be able to explain how changes in temperature cause changes of state, how forces can change motion, how adaptations help plants and animals meet their basic needs, how environmental changes can affect their growth and survival, how land formations can result from Earth processes, and how recycling can help conserve limited resources. They should be able to identify patterns in data and/or explain these patterns. They should also be able to identify and critique alternative responses to design problems.

Students performing at the *Advanced* level should be able to demonstrate relationships among different representations of science principles, as well as propose alternative explanations or predictions of phenomena. They should be able to use numbers, drawings, and graphs to describe and explain motions of objects; analyze how environmental conditions affect growth and survival of plants and animals; describe changes in the sun's path through the sky at different times of the year; and describe how human uses of Earth materials affect the environment. They should be able to design studies that use sampling strategies to obtain evidence. They should also be able to propose and critique alternative individual and local community responses to design problems.

Grade 8

For eighth grade, students performing at the *Basic* level should be able to state or recognize correct science principles. They should be able to explain and predict observations of natural phenomena at multiple scales, from microscopic to global. They should be able to describe properties and common physical and chemical changes in materials; describe changes in potential and kinetic energy of moving objects; describe levels of organization of living systems—cells, multicellular organisms, and ecosystems; identify related organisms based on hereditary traits; describe a model of a solar system; and describe the processes of the water cycle. They should be able to design observational and experimental investigations employing appropriate tools for measuring variables. They should be able to propose and critique the scientific validity of alternative individual and local community responses to design problems.

Students performing at the *Proficient* level should be able to demonstrate relationships among closely related science principles. They should be able to identify evidence of chemical changes; explain and predict motions of objects using position-time graphs; explain metabolism, growth, and reproduction in cells, organisms, and ecosystems; use observations of the sun, Earth, and moon to explain visible motions in the sky; and predict surface and groundwater movements in different regions of the world. They should be able to explain and predict observations of phenomena at multiple scales, from microscopic to macroscopic and local to global, and to suggest examples of observations that illustrate a science principle. They should be able to use evidence from investigations in arguments that accept, revise, or reject scientific models. They should be able to use scientific criteria to propose and critique alternative individual and local community responses to design problems.

Students performing at the *Advanced* level should be able to develop alternative representations of science principles and explanations of observations. They should be able to use information from the periodic table to compare families of elements; explain changes of state in terms of energy flow; trace matter and energy through living systems at multiple scales; predict changes in populations through natural selection and reproduction; use lithospheric plate movement to explain geological phenomena; and identify relationships among regional weather and atmospheric and ocean circulation patterns. They should be able to design and critique investigations involving sampling processes, data quality review processes, and control of variables. They should be able to propose and critique alternative solutions that reflect science-based trade-offs for addressing local and regional problems.

Grade 12

For 12th grade, students performing at the *Basic* level should be able to describe, measure, classify, explain, and predict phenomena at multiple scales, from atomic/molecular to interstellar. These phenomena include the structure of atoms and molecules; transformations of matter and energy in physical, Earth, and living systems; motions of objects; the genetic role of DNA; changes in populations and ecosystems due to selection pressures; earthquakes and volcanoes; patterns in weather and climate; and biogeochemical cycles. They should be able to design and critique observational and experimental studies, and they should be able to propose and critique solutions to problems at local or regional scales.

Students performing at the *Proficient* level should be able to demonstrate relationships and compare alternative models, predictions, and explanations. They should be able to explain trends among elements in the periodic table; conservation laws; chemical mechanisms for metabolism, growth, and reproduction; changes in populations due to natural selection; the evolution of the universe; and evidence for boundaries and movements of tectonic plates. They should be able to design and critique observational and experimental studies, controlling multiple variables, using scientific models to explain results, and choosing among alternative conclusions based on arguments from evidence. They should be able to compare scientific costs or risks and benefits of alternative solutions to problems at local or regional scales.

Students performing at the *Advanced* level should be able to use alternative models to generate predictions and explanations. They should be able to explain differences among physical, chemical, and nuclear changes; the wave and particle nature of light; paths of specific elements through living systems; responses of ecosystems to disturbances; evidence for the theory of an expanding universe; and evidence for human effects on the Earth's biogeochemical cycles. They should be able to design and critique investigations that relate data to alternative models of phenomena. They should be able to compare costs or risks and benefits of alternative solutions to problems at a local, regional, and global scale.

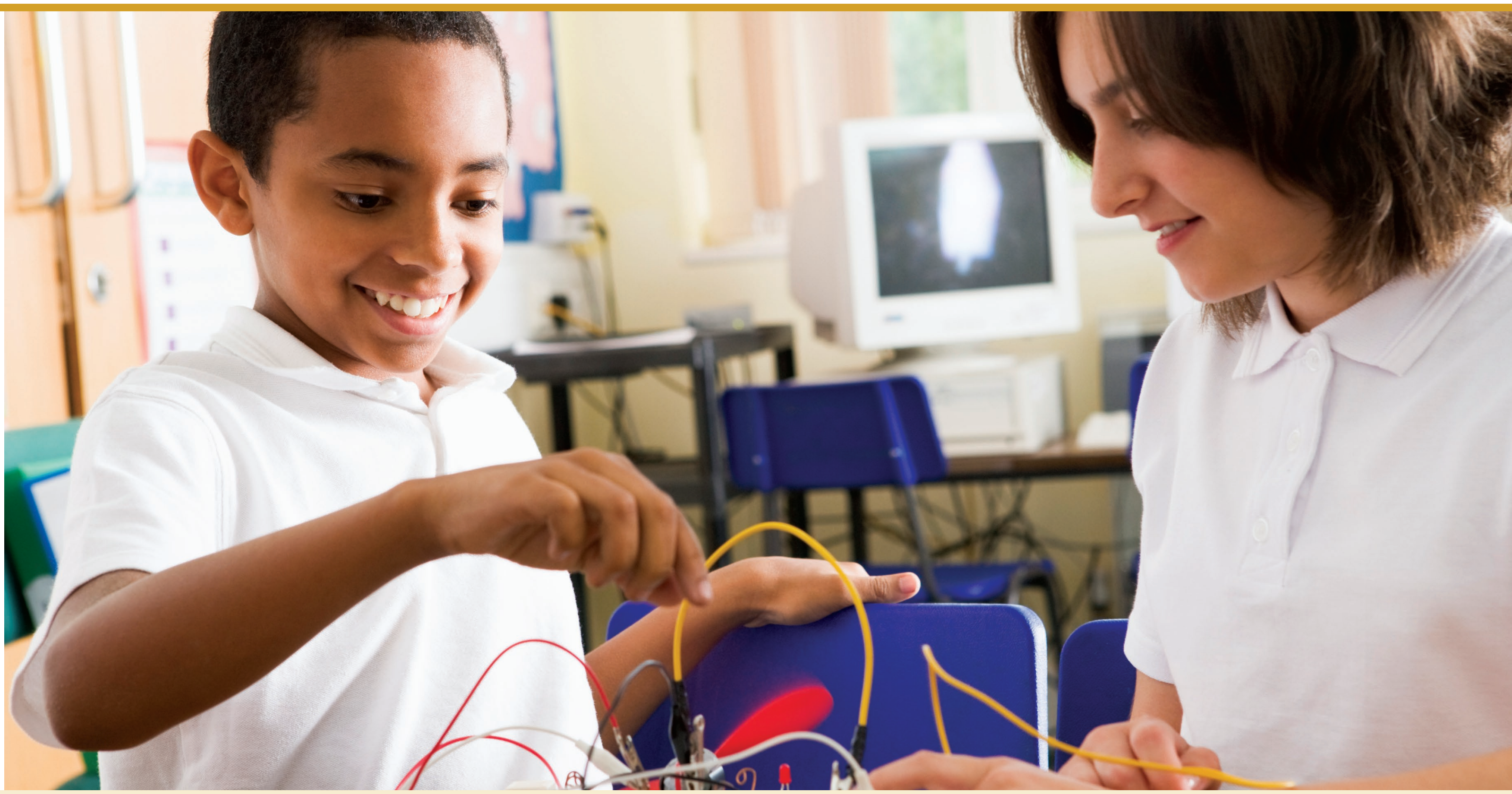
Conclusion

The 2015 NAEP Science Framework will provide a rich and accurate measure of the science knowledge and skills that students need both for their schooling and for their lives.

The Board hopes that this science framework will serve not only as a significant national measure of what students know and can do in science, but also as a catalyst to improve science achievement for the benefit of students themselves and our nation.

To access the full *2015 NAEP Science Framework* please visit http://nagb.org/publications/frameworks.htm.

The National Assessment Governing Board is an independent, nonpartisan board whose members include governors, state legislators, local and state school officials, educators, business representatives, and members of the general public. Congress created the 26-member Governing Board in 1988 to set policy for the National Assessment of Educational Progress (NAEP).



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