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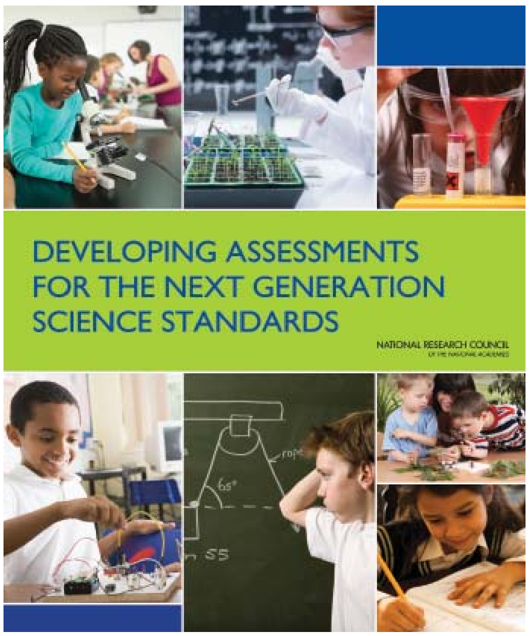
BOARD ON TESTING AND ASSESSMENT • BOARD ON SCIENCE EDUCATION

Developing Assessments for the Next Generation Science Standards



Science education in the United States is poised for dramatic change. The 2012 *Framework for K-12 Science Education* and the Next Generation Science Standards (NGSS) will reshape science education, helping students gradually develop a deep understanding of science's core ideas, practices, and cross-cutting concepts over multiple years of school. New kinds of assessments must be developed to support this vision of science learning. A new report from the National Research Council, *Developing Assessments for the Next Generation Science Standards*, describes the system of assessments that will be needed to gauge student progress.

Traditional science assessments—often tests made up of multiple-choice or short-answer questions that assess students' recall of facts—have not been designed to capture or measure the type of learning envisioned by the framework and standards. Innovation will be needed to design approaches that can evaluate students' progress toward mastering the standards.

A CLOSER LOOK AT THE FRAMEWORK AND STANDARDS

What types of assessment will be needed? As always, that depends on the knowledge and skills students are meant to develop. The National Research Council's *Framework for K-12 Science Education*—which served as the basis for the NGSS—envisions students gradually gaining deep understanding of three "dimensions" of science:

Disciplinary core ideas. The framework identifies disciplinary core ideas for the physical, life, and earth and space sciences; and for engineering, technology, and applications of science. The purpose is not to teach all the details—an impossible task—but to prepare students with enough core knowledge and skills that they can acquire and evaluate additional information on their own.

Scientific and engineering practices. This dimension includes eight important practices used by scientists and engineers as they do their work, such as asking questions and defining problems, planning and carrying out investigations, and analyzing and interpreting data.

Crosscutting concepts. This dimension identifies seven crosscutting concepts—such as "cause and effect, "systems and system models," and "energy and matter"—that have value across science and engineering. These concepts are expected to help students connect knowledge from the various disciplines as they gradually develop a coherent and scientific view of the world.

In practice, the three dimensions should not be taught in isolation from one another but should instead be integrated to support "three-dimensional learning." That is, during instruction, students' engagement in the practices should always occur in the context of a core idea and, where possible, should connect to crosscutting concepts.

ASSESSING THREE-DIMENSIONAL LEARNING

The NGSS describe specific goals for science learning in the form of *performance expectations,* statements that articulate what students should know and be able to do at each grade level—and thus what should be tested at each grade level. Each performance expectation incorporates all three dimensions, and the NGSS emphasize the importance of the connections among scientific concepts. Similarly, assessments will need to be designed to assess the three dimensions, and the report includes examples of assessment tasks, which consist of stimulus materials and multiple questions that address aspects of the three dimensions.

It will not be feasible to assess all of the performance expectations for a given grade level with a single assessment. Students will need multiple assessment opportunities to demonstrate their competence on the performance expectations for a given grade level. To adequately cover the three dimensions, assessment tasks will also need to use a variety of response formats—for example, questions that require students to supply an answer, produce a product, or perform an activity. Sets of interrelated questions should be used to assess the three dimensions. Although this challenge seems daunting, examples exist that use these types of formats.

A SYSTEMS APPROACH TO ASSESSMENT

Measuring the NGSS performance expectations and providing students, teachers, administrators, policymakers, and the public with the information each needs about student learning will require assessments that are different in key ways from current science assessments. The committee recommends a systems approach to science assessment that uses a range of strategies and information to provide results that complement one another. The system should consist of three parts:

Assessments designed to support classroom instruction. Some classroom assessments should provide information that teachers can use to identify areas where students are making progress or struggling and adjust their instruction accordingly; these "formative" assessments can be used at any point in students' coursework. Other classroom assessments can be used for "summative" purposes—to evaluate student learning and assign grades at the end of a course.

Assessments designed to monitor science learning on a broader scale. Assessments designed for monitoring purposes, often referred to as "large-scale" assessments, are used to audit student learning over time and to evaluate the effectiveness of the science education system and its parts. Given the breadth and depth of material covered in the standards, new approaches will be needed to monitor students' learning. The committee recommends that monitoring assessments consist of two parts. The first part would consist of the standardized assessment developed by the state and given at a time set by the state. Such assessments are already used in most states; however, these assessments will need to be designed so that they use the types of tasks and response formats that assess three-dimensional learning.

The second part would consist of "classroom-embedded" assessments. These would also be designed by the state, but they would be administered at a time that fits the instructional sequence in the classroom, as determined by the district or school. Classroom-embedded assessments could take various forms; they might be self-contained curricular units that include both instructional materials and assessments, or the state or district could develop banks of tasks that could be used at the appropriate time in classrooms. Information from both parts of the monitoring assessments would be combined to audit student learning and evaluate the effectiveness of the science education system.

Indicators designed to track opportunity to learn. It is important to ensure that the dramatic changes in curriculum, instruction, and assessments prompted by the framework and NGSS do not exacerbate current inequities in science education, but begin to reduce them, while raising the level of science learning for all students. Information should be routinely collected to monitor the quality of the classroom instruction students receive, to determine whether all students have the opportunity to learn science in the way called for in the framework, and to see whether schools have the resources they need to support learning (i.e., teachers who have adequate subject area knowledge, time, and materials, etc.).

IMPLEMENTING THE NEW ASSESSMENT SYSTEM

The systems approach to science assessment that the report advocates cannot be reached by small

Example: Assessing Three-Dimensional Learning

How can three-dimensional learning be assessed? The following example describes a cluster of three tasks that ask students to determine which zone of their schoolyard contains the greatest biodiversity. The tasks require students to demonstrate their knowledge of one disciplinary core idea (biodiversity) and one crosscutting concept (patterns) with three different scientific practices: planning and carrying out investigations, analyzing and interpreting data, and constructing explanations. This is an example of formative assessment: tasks that can help teachers spot strengths and weaknesses in students' understanding and modify their instruction accordingly.

<u>Task 1:</u> ***Collect data on the number of animals (abundance) and the number of different species (richness) in schoolyard zones.*** The students split into three teams, and each team is assigned a zone in the schoolyard. The students are instructed to go outside and spend 40 minutes observing and recording all of the animals and signs of animals seen in their assigned zone. The students use an Apple iPod to record their information. The data are uploaded and combined into a spreadsheet that contains all the students' data.

Purpose: Teachers can look at the data provided by individual groups or from the whole class to gauge how well students can perform the scientific practices of carrying out investigations and collecting and recording data.

<u>Task 2:</u> ***Create bar graphs that illustrate patterns in abundance and richness data from each of the schoolyard zones.*** Each student is instructed to make two bar charts—one illustrating the abundance of species in the three zones, and another illustrating the richness of species in the zones—and to label the charts' axes.

Purpose: This task allows the teacher to gauge students' ability to construct and interpret graphs from data—an important element of the scientific practice "analyzing and interpreting data."

<u>Task 3:</u> ***Construct an explanation to support your answer to the question, which zone of the schoolyard has the greatest biodiversity?*** Previously, students had learned that an area is considered biodiverse if it has both a high animal abundance and high species richness. In the instruction for this task, each student is prompted to make a claim, give their reasoning, and identify two pieces of evidence that support their claim.

Purpose: This task allows the teacher to see how well students understand the core idea of biodiversity and whether they can recognize data that reflects its hallmarks (high animal abundance and high species richness). It also reveals how well they can carry out the scientific practice of constructing explanations. This task could also be used as part of a "summative" end-of-unit assessment.

modifications to the old system. Rather, the Next Generation Science Standards represent a fundamentally different approach to defining science achievement that will require a very different approach to assessment.

To make the transition to an assessment system that supports the vision of the framework and NGSS, a systematic but gradual process that reflects well thought out priorities will be needed. State leaders and educators should expect the development and implementation of the new system to take place in stages over a number of years. This will need to include changes in instruction, curriculum, assessment, and professional development for teachers.

The new assessments should be developed with an approach that is "bottom up" rather than "top down"—one that begins with the process of designing assessments for the classroom, perhaps integrated into instructional units. Placing the initial focus on assessments that are close to the point of instruction will be the best way to identify successful ways to teach and assess three-dimensional science knowledge. These strategies can then serve as the basis for developing assessments at other levels, including those used for accountability.

FOR MORE INFORMATION... This brief was prepared by the Division of Behavioral and Social Sciences and Education based on the report *Developing Assessments for the Next Generation Science Standards*. The study was sponsored by the S.D. Bechtel, Jr. Foundation, Carnegie Corporation of New York, and the William and Flora Hewlett Foundation. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not reflect those of the sponsoring organizations. Copies of the report are available from the National Academies Press; (800) 624-6242; http://www.nap.edu.

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