21st Century Science Assessment: The Future Is Now

By James W. Pellegrino, Learning Sciences Research Institute University of Illinois at Chicago | February 2016

James Pellegrino's influential research on student learning, instruction, and assessment has helped shape how students learn in the 21st century. In this paper, Pellegrino reflects on the need for substantial change in what we expect students to know and be able to do in science, how science should be taught, and how science competency should be assessed. Pellegrino co-chaired the National Academy of Sciences committee tasked with developing assessments for the Next Generation Science Standards.

Executive Summary

Science education in the United States is undergoing dramatic change as a result of the 2012 *Framework for K-12 Science Education*. Drawing on decades of research in science education, this document describes a vision for science learning whereby students gradually deepen their understanding of three core dimensions of science: disciplinary core ideas, scientific and engineering practices, and crosscutting concepts.

For this vision to come to realization, however, new kinds of science assessments must be developed to serve as indicators of progress in providing educational opportunities consistent with today's goals for STEM education. The National Research Council's 2013 report *Monitoring Progress Toward Successful K-12 STEM Education* recommends the collection of data on two indicators related to science assessment:

- States' use of assessments that measure the core concepts and practices of science disciplines
- Inclusion of science in federal and state accountability systems.

A Systems Approach to Science Assessment

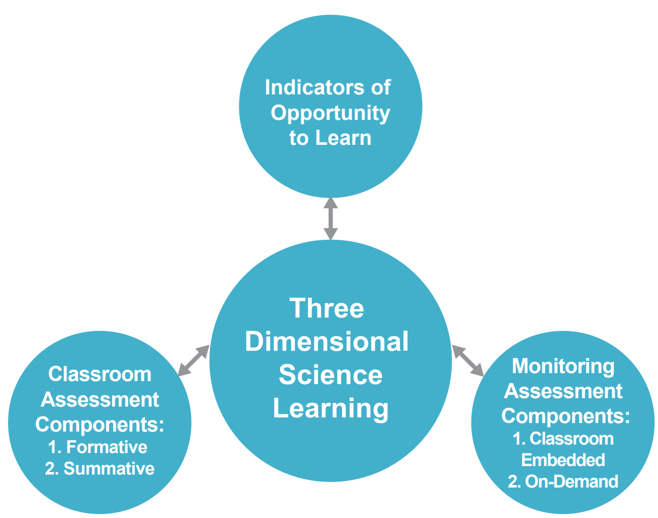
Learning assessments are used by multiple audiences and for different purposes—from classroom teachers to state and national policy makers. To provide the data and information this diverse set of stakeholders requires, a systems approach is necessary to create a science assessment system consisting of the following three parts:

1. **Assessments designed to support classroom instruction.** These include formative assessments that teachers can use to identify areas where students are making progress or struggling so that they can adjust their instruction accordingly, as well as summative assessments to evaluate student learning and assign grades at the end of a course.

2. **Assessments designed to monitor science learning on a broader scale.** These are large-scale assessments used to audit student learning over time and to evaluate the effectiveness of the science education system. Monitoring requires not only state-developed standardized assessments, but also classroom-embedded assessments that fit the instructional sequence of local schools.

3. **Indicators that track learning opportunities.** In this part of the assessment system is regularly collected information about the quality of classroom instruction to determine whether all students have the opportunity to learn science as described in the *Framework* and to signal whether additional resources and supports are needed.

Assessing all the performance expectations for a given grade level with a single assessment is not possible. Students will need multiple opportunities to demonstrate their competence across the three core dimensions of science outlined in research-based science education reform documents. A focus on assessment design that is carefully aligned with the *Framework* is essential for sending the right signals about what students should know and be able to do when demonstrating competence in science.



How Can We Assess Science Competence?

We assess students to find out what they know and can do, but assessments are not direct pipelines into their minds. Rather, an assessment is a tool for observing students' behavior and producing data that can be used to draw reasonable inferences about what students know. To be reliable tools for assessing student competence, *Framework*-aligned assessments will have the following key design elements:

- **Assessment variety.** Classroom assessment should include various types of evidence about student learning, such as a classroom discussion in which students explore and respond to each other's ideas, a formal test or diagnostic quiz, or the evaluation of artifacts that are the product of classroom activities.
- **Multicomponent tasks.** Central to the *Framework for K-12 Science Education* is the research-based insight that science competence requires the ability to integrate disciplinary core ideas, scientific and engineering practices, and crosscutting concepts. Aligning with the *Framework* therefore means that assessment tasks must be composed of more than one kind of activity or question. Only through multicomponent tasks will students have the opportunity to demonstrate their ability to orchestrate these three dimensions of scientific competence.
- **Connections.** Because science education research emphasizes the importance of the connections among scientific concepts, assessment tasks will need to be designed to provide information about students' capacity to make these connections.
- **Student progress.** Learning is a trajectory along which students gradually progress in the course of a unit, a year, and across the K-12 grades. Thus, it is important that classroom assessments help teachers and students understand where students are relative to expected levels of progress.

Assessment is a key element in the process of educational change and improvement. Done well, it can signify what it is that we want students to know and be able to do and can help educators create the learning environments that support attainment of those objectives. Done poorly, it sends the wrong signals and skews the teaching and learning process toward teaching to tests that have little relationship to the competencies students will need in the future.

Implications for Practice and Policy

A single assessment type cannot serve all the appropriate purposes and needs of stakeholders in the educational system. Thus, **policy makers and state and district leaders need to promote a balanced and coordinated system of multiple assessments that work together with curriculum and instruction to promote science learning.**

Assessments of the three dimensions of science learning are challenging to design, implement, and interpret. Thus, **policy makers should allocate adequate funding for teacher professional development initiatives to support the uptake into classroom practice of assessments aligned with research-based, rigorous standards.**

To provide indicators of progress toward attaining STEM education goals, **state education leaders should provide clear guidelines that define forms of evidence that can be mapped to beginning, intermediate, and sophisticated levels of science knowledge and practice that are expected across grade levels.**

To develop students' skills and dispositions in science and engineering, **teachers should use curriculum materials and assessment tasks that require students to engage in practices that demonstrate their understanding of core disciplinary ideas and crosscutting concepts.**

Students require ongoing feedback about their science learning to succeed and stay motivated. To assist students during the learning process, **teachers need to make use of formative assessment tasks that can guide their instructional decision making in the classroom and provide students with information about which skills and knowledge they need to study further.**

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Silicon Valley
(SRI International headquarters)
333 Ravenswood Avenue
Menlo Park, CA 94025
+1.650.859.2000
education@sri.com

Washington, D.C.
1100 Wilson Boulevard, Suite 2800
Arlington, VA 22209
+1.703.524.2053

www.sri.com/education