Report offers new framework to guide K-12 science education, calls for shift in the way science is taught in US

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A report released today by the National Research Council presents a new framework for K-12 science education that identifies the key scientific ideas and practices all students should learn by the end of high school. The framework will serve as the foundation for new K-12 science education standards, to replace those issued more than a decade ago. The National Research Council is the operating arm of the National Academy of Sciences and National Academy of Engineering; all three are independent, nongovernmental organizations.

The committee that wrote the report sees the need for significant improvements in how science is taught in the U.S. The new framework is designed to help students gradually deepen their knowledge of core ideas in four disciplinary areas over multiple years of school, rather than acquire shallow knowledge of many topics. And it strongly emphasizes the practices of science – helping students learn to plan and carry out investigations, for example, and to engage in argumentation from evidence.

The overarching goal of the framework, the committee said, is to ensure that by the end of 12th grade, all students have some appreciation of the beauty and wonder of science, the capacity to discuss and think critically about science-related issues, and the skills to pursue careers in science or engineering if they want to do so -- outcomes that existing educational approaches are ill-equipped to achieve.

"Currently, science education in the U.S. lacks a common vision of what students should know and be able to do by the end of high school, curricula too often emphasize breadth over depth, and students are rarely given the opportunity to experience how science is actually done," said Helen Quinn, committee chair and professor emerita of physics at SLAC National Accelerator Laboratory in Stanford, Calif. "The new framework is designed to address and overcome these weaknesses. It builds on what is known to work best in science education, based on research and classroom experience both in the U.S. and around the world. It provides a blueprint that will guide improvements in science education over many years."

The framework was developed by an 18-member committee that included experts in education and scientists from many disciplines. The committee publicly released a draft in summer 2010 to obtain and incorporate feedback from the broader community of scientists, science educators, educational policymakers, and education researchers.

The framework is the first step in the development of new K-12 science education standards. The framework lays out the broad ideas and practices students should learn and will serve as the basis for specific standards, which will be developed in a process led by a group of states and coordinated by the nonprofit educational organization Achieve Inc. When the standards are finished, states may voluntarily adopt them to guide science education in their public schools.

In addition to serving as the foundation for the development of new standards, the framework can be used by others who work in K-12 science education, such as curriculum and assessment developers, those who train teachers and create professional development materials, and state and district science supervisors.

Science as Both Ideas and Practices

The framework specifies core ideas in four disciplinary areas -- life sciences; physical sciences; earth and space sciences; and engineering, technology and the applications of science -- that all students should understand by the time they finish high school. For example, among the core ideas in the physical sciences are "matter and its interactions" and "energy." Students' knowledge of these ideas should deepen over time, and the framework specifies aspects of each idea that students should know by the end of grades two, five, eight, and 12.

The framework also identifies seven crosscutting concepts that have explanatory value across much of science and engineering, such as "cause and effect" and "stability and change." These concepts should be taught in the context of core ideas from the disciplines of science, the report says, but teachers should use a common language for these concepts across disciplines, so that students understand the same concept is relevant in many fields. These concepts should become familiar touchstones as students progress from kindergarten through 12th grade.

Just as important are scientific and engineering practices, which have been given too little emphasis in K-12 education, the committee said. The framework specifies eight key practices that students should learn, such as asking questions and defining problems, analyzing and interpreting data, and constructing explanations and designing solutions. These practices should be integrated with study of the disciplinary core ideas and applied throughout students' K-12 education.

These three dimensions must be used together for students to understand how science works, the committee stressed. For example, students should use the practices -- such as conducting investigations and then analyzing and interpreting the data -- to deepen their knowledge of the core ideas.

Putting the Framework to Use

The report offers guidance to those who will use the framework to develop new science education standards. The standards should set rigorous learning goals that represent a common expectation for all students. They also should be limited in number to reflect the framework's focus on a small set of core ideas and practices, and should include guidance about what does and does not need to be taught.

Developing new standards is a key step in making K-12 science education more coherent and effective, but it is far from the only one, the committee said. Curricula will need to incorporate the framework's ideas and practices, and teacher preparation and professional development programs should provide ways for teachers to deepen their own conceptual understanding of the practices and ideas of science. Assessments will need to be linked to the shared goals outlined by the framework and related standards. And time, space, and resources for science learning need to be made available. "For all students to have the opportunity to learn the ideas and practices we've described, many other players and parts of the system will need to change, some in fundamental ways," said Quinn.

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