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COMMENTARY
Science Standards Require a Teacher-Learning Rethink
By Jean Moon, Sarah Michaels, & Brian J. Reiser

Science education is giving us an opportunity to rethink the state of professional development and preservice education for teachers. The specific opportunity creators are two complementary documents: the Framework for K-12 Science Education (released in 2011 by the National Research Council, of which Brian J. Reiser is a member and contributing author), which identifies key scientific and engineering practices that all students should master by the time they graduate from high school; and the voluntary Next Generation Science Standards, which will be released in early 2013. The framework rests on well-respected research about how children learn and the ways in which to develop supportive environments for coherent science learning. The standards will identify student-performance expectations aligned with the framework. When finalized, the Next Generation Science Standards will offer a set of science standards—like the English/language arts and math common core—that can be held in common across all states that elect to adopt them.

But how do we prepare teachers for instruction of the science standards?
Much has been learned generally about effective professional development, shifting both the narrative and vocabulary. Terms such as "teacher training" are being replaced by an understanding of teaching as a professional practice built on deep subject-matter knowledge, knowledge of students' progressive conceptual development, and the use of evidence to inform instructional judgments. Despite a deepening research base on professional practice, research-derived principles are still too often ignored.

Indeed, we know that one-shot, topic-oriented, technique-driven, one-size-fits-all professional "training" is not effective. Stephanie Hirsh, in an Education Week Commentary earlier this year, called it the "spray and pray" approach, which exposes everyone to the same material in the hope that some of it sticks. We must carry no illusions that the kind of teaching practices needed for the multidimensional and integrated framework (and, by extension, the science standards) can be cultivated in disconnected, one-shot learning experiences. New models are required to support teachers and preservice education students in developing the deep craft knowledge necessary to weave together the three dimensions the framework identifies: disciplinary core ideas, crosscutting concepts, and science and engineering practices.

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The key elements for designing professional development and preservice courses supportive of the framework and the science standards are as follows:

First, teacher professional-development and preservice-learning experiences should start with what is new—supporting students' ability to build scientifically based explanatory ideas over time, making conceptual connections across scientific disciplines, and involving learners in science and engineering practices to construct and apply these ideas. Second, research on professional development and preservice education must be the sure foundation upon which new models of professional learning are built.

There are five research-based principles to consider for supporting productive and positive teacher-learning practices:
• Teacher-learning experiences should include what the framework and the standards are asking all students to learn. Student learning and teacher learning are inextricably linked; teachers cannot teach what they themselves cannot do.
• Teacher-learning experiences need to be close to the classroom. They must be relevant, recognizable, and realistic. Teachers should see, hear, and feel what this new vision of science looks like with students that compare to their own, over extended periods of time, in order to recognize the implications and adapt their practice.
• Teacher learning requires working with rich images of desired practice. These shifts in teaching and learning go beyond modifications of instruction. They call for an ability to engage students in building and refining scientific knowledge.
• Teacher-learning experiences should provide educators with models of expertise in different formats. Examples include videos of real classrooms, scientists' and engineers' perspectives on the role of particular practices such as modeling, and print and technology-based resources.
• Resources and teacher-learning experiences must be scalable, widely accessible, and interwoven into a well-coordinated system of expertise, resources, tasks, and tools adaptable to different learning contexts.
Any new genre of teacher professional development should bring together these principles in a highly specific, mutually reinforcing, coherent system of learning.

The strength of a system-based model is twofold: to provide usable resources, tools, and classroom images in meaningful teacher-learning contexts; and to expose problems in practice within a classroom context and then to support teachers as they investigate those problems.

Specifically for science education, professional-learning systems can now be built around a library of video or digitized exemplars of teachers and students in diverse classrooms, working on weaving together core disciplinary ideas, scientific and engineering practices, and crosscutting ideas. These classroom exemplars are crucial not because they provide images of perfected teaching practice, but because they provide an important window on instruction and curriculum to support the sustained exploration and analysis of teaching practice and student learning.

With advances in network technologies, the Web can offer high-quality teacher-learning resources. For example, images of diverse classrooms with students progressing in their science learning and teachers developing their practice, used over time, could become critical anchor points in changing instructional patterns. Just as it is difficult to teach what one does not know, it is difficult to teach what one cannot even imagine.

More efforts are needed, however. While video can provoke, inspire, demonstrate, even challenge, it is unlikely to change practice for the long term. A reinforcing system of well-crafted and linked tools, tasks, and resources, including classroom images, should be the overall goal. Likewise, new professional-development and preservice models must recognize that professional-learning contexts are changing.

Today, educators from across the country and the world are self-organizing into asynchronous study groups. And national member organizations, like the National Science Teachers Association, are creating online professional-development experiences to meet member needs, in the midst of diminishing state and district budgets.

The point is that any new system-based model of professional learning for science educators will need to support a range of delivery configurations or learning pathways so that the experience is shareable, scalable, and sustainable. The power and reach of a networked world is now available to reinforce the integration of professional learning with professional practice, regardless of location, district resources, or expertise.

Changes needed in science education are not small tweaks. The NRC Framework for K-12 Science Education along with the Next Generation Science Standards set the bar quite high. The framework is a road map that could transform science teaching and learning. To increase the odds of a successful transformation in a reasonable time frame, professional development and preservice education in science should be taken seriously and prioritized. New models can be built on an infrastructure of proven research in support of professional practice, integrated with classroom exemplars and resource-rich learning systems, aligned to the framework's road map, and supportive of student-performance expectations found in the science standards.

Jean Moon is the founder and principal of Tidemark Institute, a national and international voice in science, technology, engineering, and mathematics, or STEM, education, located in Damariscotta, Maine. Sarah Michaels is a professor of education, the director of the communication and culture program, and a senior research scholar at the Hiatt Center for Urban Education at Clark University in Worcester, Mass. She is a co-author of the NRC-sponsored practitioner volume, Ready, Set, SCIENCE!: Putting Research to Work in K-8 Science Classrooms (National Academies Press, 2008). Brian J. Reiser is a professor of learning sciences at Northwestern University in Evanston, Ill. He was a member of the National Research Council panels that wrote "Taking Science to School" (2007) and "A Framework for K-12 Science Education" (2011).