EDUCATION WEEK
Published Online: January 6, 2015
Published in Print: January 7, 2015, as **For Integrating STEM, Experts Recommend Teaching Nanoscience**

Lessons on Small Particles Yield Big Gains, Say Proponents

Topic also points students to new careers

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As schools look for ways to implement the Next Generation Science Standards, some scientists and educators argue that schools should start small—really, really small.

The topic they have in mind is nanoscience, the study of particles in the range of a billionth of a meter. To put that in perspective, one strand of human DNA is a little more than 2.5 nanometers, and there are about **1 million nanometers in the period at the end of this sentence.**

Nanoscience is a rapidly expanding part of fields from medicine to high-tech manufacturing. Federal and industry experts at a National Science Foundation meeting last month believe it could provide a path to break down some of the silos separating science, technology, engineering, and mathematics classes and link their concepts to future careers for students.

"We focus a lot on the pure sciences, the sizes and scales and models and simulations, but [students'] eyes really get wide and they really get excited when they see gold turn red at the nano scale, or you take them to the lab and they see carbon nano-fibers being spun," said Daphne Schmidt, the coordinator of professional development at the MathScience Innovation Center in Richmond, Va., intended to provide STEM-related professional development and informal science learning.

"This is really about expanding the scale of understanding," she added. "It's not new; it's just a more holistic way of teaching science."

Leading the Way

Among states, Virginia is at the leading edge of the effort to promote nanoscience education. In its 2010 science-standards revision, the state added recommendations for ways to use nanoscience applications in existing topics. For example, as part of physics, the revised standards suggest students learn to understand how high-powered equipment such as atomic force microscopes and scanning tunneling microscopes are used to determine nanoscale properties and forces.

"We have to institutionalize nanoscience and technology into the curriculum for all K-12 students throughout the United States," said James G. Batterson, a retired aerospace engineer with NASA and a former teacher in the Newport News, Va., school district who consulted on Virginia's new science standards. "We've seen what happens if you don't institutionalize it. The wealthy schools and parents make sure their students get it, and the students in poor schools don't."

Yet in most states, nanoscience is not an explicit part of the curriculum. The Next-Generation Science Standards, which have been adopted by 26 states, don't use the words "nanoscale" or "nanoscience," but the field offers a way to organize and approach many existing topics, like properties of atoms or exponential notation, said Patricia Simmons, a past president of the Arlington, Va.-based National Science Teachers Association, at the NSF meeting.

Integrating STEM

For example, Jonathan Home, the leader of the Trapped Ion Quantum Information Group, a team at the Institute for Quantum Electronics in Zurich that is building a computer tinier than an atom, suggested that high school math teachers could use nanotechnology to give a new "spin" to teaching matrix problems—those with sets of numbers—in algebra. Electrons' spin has both magnitude and direction, and problems using them might be calculated using two-by-two matrices, said Mr. Home, who was not at the meeting. "I think students at most schools can multiply two-by-two matrices—at least we did at school—so they would also see the relevance of matrices to the real world."

Becoming more oriented to processes and practical applications can also help schools keep up with rapid advancements in science, said Anne Lynn Gillian-Daniel, the education director for the Materials Research Science and Engineering Center at the University of Wisconsin-Madison. "Kids are still memorizing what amino acids look like," she said. "Why? I can look that up on Google in 10 seconds."

Instead, she argued, students should be learning how to pull together concepts and techniques from different branches of science, and using communication and writing skills, to complete projects.

Celia I. Merzbacher, the vice president for innovative partnerships at the Semiconductor Research Corporation, in Durham, N.C., agreed. She surveyed leaders of businesses hiring in nanoscience industries and said nanoscience careers call for more interdisciplinary understanding of science, technology, engineering, and math.

"These people are living in a team environment, working with others coming from different disciplines, and they need to have both the knowledge—and the ability to continue to learn—to thrive in that kind of environment."

Many careers associated with nanotechnology—from an aeronautical engineer fashioning 1.3-nanometer carbon tubes to make super-strong materials to a pharmaceutical researcher designing cancer treatments smaller than a single cell—require students to move smoothly among different fields, she said.

But such cognitive flexibility can be difficult to teach. "We don't know as much about interdisciplinary learning at any level to be able to build a workforce for this converging workplace," said Susan R. Singer, an NSF division director. "The beauty of the kind of work we are seeing [in nanoscience education] is it is very tightly linking learning and understanding to specific fields."

It's a challenge, too, to prepare teachers and provide support for them to work together across disciplines, said Ms. Schmidt of the MathScience Innovation Center. The center has developed a fellowship program that trains teachers with a three-day summer boot camp on concepts and experiments using nanoscience, followed by in-person and online meetings throughout the year for teachers to discuss how the experiments played out in the classroom and share successful practices.

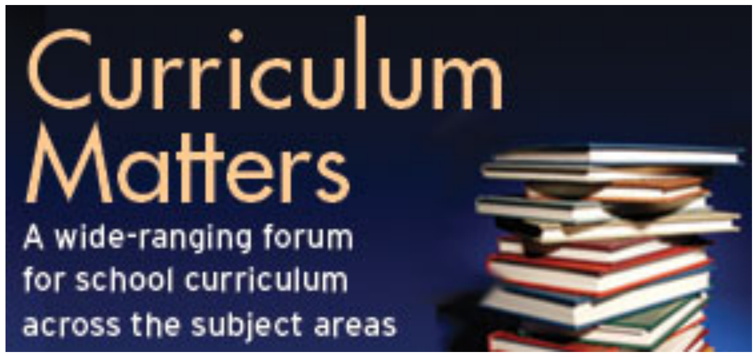
"It's beautiful in a way, because that's how science works in the real world, but it's tough coming out of our silos," Ms. Schmidt said.

The center now has 13 Virginia school divisions in a consortium testing nanoscience instructional materials, and has trained more than two dozen middle and high school teachers in the last three years.

Not 'Just One More List'

The greatest danger, educators and scientists at the meeting warned, is that nanoeducation might become "just one more list" of concepts for students to memorize rather than more-practical applications for students to explore.

"Listing groups of particles in astronomy, or talking about nanoscience, might inspire students to be interested in physics, which is good," Mr. Home said, "but I think there is very little development of the mind that goes on if you do this too early" in the elementary grades.



But Ms. Simmons argued that even primary-grades students should learn scientific processes and get a chance to experiment with them. "Students will either turn off to sciences or turn on to sciences in the upper-elementary level," she said. "In elementary you ask who's a scientist and everyone raises their hands. By middle school you ask the same question and everyone points to one kid at the back of the class."

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