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What the future of science education should look like

By Valerie Strauss April 20

Science is one of those subjects that everybody agrees is of the highest importance but somehow manages to get short shrift when it comes to policy. In the following post, Arthur H. Camins looks at where science education has been and what it should look like. Camins is the director of the Center for Innovation in Engineering and Science Education at the Stevens Institute of Technology in Hoboken, N.J. He has taught and been an administrator in New York City, Massachusetts and Louisville, Kentucky. The ideas expressed in this article are his alone and do not represent Stevens Institute.

By Arthur H. Camins

For over five decades, dramatic calls for schools to improve science literacy have been driven by fears of external economic and military domination. Despite inducements to change, and a half-century of research-based consensus that students would be well served by more active learning and less lecture and memorization, the latter practices are still ubiquitous. While we remain the world's leading generator of science and engineering innovation, far too many Americans lack sufficient understanding of the foundational principles of the scientific investigations and engineering designs that have improved our lives.

As a result, they are unable to fully engage in informed participation in debates about such critical issues as climate change, sustainable development and genetic engineering or evaluate the relative risks implicit in ubiquitous side-effect messages in televised drug advertisements. In addition, we have made far too little progress in diversifying the STEM workforce in ways that would surely benefit the lives of all Americans.

In large measure the success of our nation depends on the extent to which it harnesses the power and promise of science and engineering in pursuit of a better life for all of its citizens. Students' experience in school can either advance or hinder advancement depending on whether or not the full diversity of learners' interest, passion and creativity are engaged. We are not now on a pathway to success, but we could be. In a significant step forward, the National Research Council developed a Framework for K-12 Science Education. With further input from scientists and educators, the Framework was further specified as the Next Generation Science Standards (NGSS).

These are not perfect documents, but together they point educators in a positive direction in three significant ways.

First, the Framework promotes the idea that understanding the designed world is an essential feature of science literacy. After all, it is through the systematic, iterative process of engineering that results of scientific investigation are translated into processes and products that result in either improvement or deterioration of our lives.

Second, the Framework and NGSS make the case for a substantial change in what happens in science classrooms. It wants students not to simply memorize what scientists already know but engage in the practices of scientists and engineers in order to understand– and potentially participate in – figuring out and explaining the natural world. Decades of learning science research suggest that this approach is far more likely to result in durable, usable knowledge. This learning includes developing the expertise to evaluate whether scientific explanations and arguments are supportable, refutable or in need of revision.

The third important idea is that scientific literacy is not just specialized knowledge for the gifted few or those who choose science or engineering as a career, but essential for life and citizenship. For example, one goal of the Framework is for students to understand the influence of engineering, technology, and science on society and the natural world. The NGSS translates this into what students should be able to do: *Evaluate or refine a technological solution that reduces impacts of human activities on natural systems*. These are important talents not just for the professionals, but also for voters who can evaluate and then influence the direction of policies.

Whether these positive developments result in deep, sustainable change depends on how and whether federal funds support science education at the state level and how states legislatures and departments of education handle several critical issues. Learning from failure is an essential feature of the engineering design process. So it should be in the design of education systems.

Improvement will require investment. Prior efforts to improve the quality, depth and diverse reach of science learning stumbled when promising curricular and instructional innovations were not supported with sufficient material resources or professional development.

Active learning requires materials for student investigations, as well as the time and space for teachers to learn, practice and refine new instructional approaches. Unless these essential dimensions are addressed fully and in ways that mediate current property taxed-based resource inequities, there is little hope for progress.

Substantive, sustained improvement will also require patience. Past education improvement efforts have been undermined by impatience for quick, easily measurable results. Measurement is important, but not because rewards and punishments magically lead to improvement. Measurement of learning is essential precisely because the Framework challenges current practice and because the ways in which its vision will be realized still require experimentation and learning from failure. Flexibility and tolerance for risk are essential for evaluation and refinement of innovations.

As a result, success hinges on whether or not states rush to develop and implement consequential assessments of science and engineering learning. In 2014, the National Research Council released a report that recommended a carefully sequenced iterative approach to assessment development that included monitoring opportunities to learn, classroom assessments designed to support instruction and broad measures of achievement potentially through periodic sampling techniques rather than yearly testing of every student. State education departments would be wise to enact assessment systems in that order.

Policymakers need to move beyond the half-century old fear narrative. They also need to abandon the discredited notion that consequential assessments can be the primary driver of improvement, and enable educators with the heretofore, unavailable gift of sufficient time and resources.

Valerie Strauss covers education and runs The Answer Sheet blog.
