

Why All Scientists Should Promote Science Outreach

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The Next Generation Science Standards (NGSS) focus on empowering U.S. students with the skill of using evidence and logic to solve problems in the natural sciences, with an emphasis on the “practice of science”. As such, they represent a substantial step forward in the continuing effort to eliminate a traditional way of teaching science, in which students are expected to regurgitate phrases in textbooks, with the sole aim of making sure that students “know” what scientists have discovered about the natural world.

I am convinced that we urgently need a major redefinition of what is meant by the term “science education”, especially because the traditional approach has turned generations of students away from science, including many of today’s political leaders. This ambitious goal will require a great deal of effort from scientists, starting with changing how we teach our own college science classes. STEM professors must move away from the standard 50-minute lecture to incorporate active learning techniques, as can readily be done even in large college classes (see <https://www.nap.edu/catalog/18687/reaching-students-what-research-says-about-effective-instruction-in-undergraduate>). And to support improvements at lower levels, scientists and engineers should be reaching out energetically to both teachers and their communities to ask how they can best help. Critical guidance for the latter task will come from the researchers who develop and implement programs that connect formal and informal educators with practicing STEM professionals – providing an important reason for establishing this new Journal of STEM Outreach.

There are many challenges ahead. For example, after a stellar career as a yeast geneticist (Nobel Prize, 2001), my friend Lee Hartwell is now working to produce curricula designed to improve science education in middle school. He strongly believes that students at that age should be exposed to an authentic science experience. Lee claims that this “means exploring the unknown. Nearly all science projects for schools involve repeating something that is well established so the goal is to get the right answer. That is not science. It is analogous to offering a history of art class to someone who wants a painting class.” I agree, and I share Lee’s belief that it is critical to build off such experiences to teach how the scientific community operates to continually advance humanity’s understanding of how the world works. This will require the development of exciting new curricula that enable students to understand the difference between science with a small “s” (what an individual scientist claims that he or she has discovered) and Science with a capital S (what the scientific community concludes; see <https://arxiv.org/pdf/1704.01614.pdf>). This cannot be left to the customary chapter in middle school textbooks on “the nature of science”, which would fail to interest even the most scientifically inclined 12 year old. At the upper-level high school and first-year college levels, reading and dissecting a scientific journal article is powerful way to teach the nature of science, and the AAAS has produced a free website with nearly a hundred, carefully selected Science magazine articles that have been annotated expressly for this purpose (see <http://www.scienceintheclassroom.org/>).

How can scientists and engineers best help teachers convey the excitement of science by allowing students to experience something that resembles science itself? Through partnerships, we can help local teachers make the science learning in their classes both motivating and enjoyable for students. And by working closely with groups of outstanding K-12 teachers, we can use our influence at state and local levels to prevent them from being suffocated by stifling, top-down requirements. For example, we must pay close attention to the tests that are designed to hold science teachers “accountable”, knowing from recent “No Child Left Behind” disasters that poor high-stakes, multiple-choice tests will strongly incentivize poor teaching.

Finally, scientists should be paying close attention to what modern education research demonstrates to be the most effective pedagogies. Fortunately, this information is now readily accessible through many free PDFs from the National Academies (see <https://www.nap.edu/topic/282/education>), as well as through open access, high quality education journals – for example, both this new publication and the 15-year old journal LSE (see <http://www.lifescied.org/>).

To improve the science of education, a non-profit organization called the Strategic Education Research Partnership (SERP) was formed in 2003, based on a pair of National Academies’ studies. These studies had asked why research is used to continually improve activities like agriculture and medicine, but not education. SERP was created to help change that

situation by directly connecting teams of the nation's best education researchers and developers with skilled practitioners in our public school systems. As SERP Board chair, I have come to appreciate the fact that most students learn best from meaningful interactions with other students. Thus, a "5 X 8 Card" that SERP produced to help principals evaluate the classes that they visit requires answers to questions such as: "How many times did "students say a second sentence to expand or explain their thinking?", and "How many times did "students talk about each others thinking" (see <http://serpinstitute.org/>). (I have thereby come to appreciate why one laptop per two or three students is better – and of course less expensive -- than one laptop per child). And for science education, SERP has just produced "Scigen", 24 free open-education resources filled with fun, interactive assets designed to produce joyful, effective learners in middle school (see <http://serpmedia.org/scigen/>).

Urgently needed now is research that focuses on how we can best harness modern technologies to prepare curricula in ways that will enable most teachers to teach science well, without requiring massive amounts of expensive teacher professional development. This too will be an important part of "making a science out of science teaching", and it is yet one more area where engaging the skills of outstanding scientists and engineers will be critical.