The NGSS and STEM Instruction: Two Intersecting Initiatives

Ed Robeck

The *Next Generation Science Standards* (NGSS)[i] have emerged at a time when science education is responding to calls for integrating dimensions of science, technology, engineering, and mathematics (STEM) knowledge and practices into preK–12 science curricula and instruction. The emphasis in the NGSS on "Science and Engineering Practices," and the attention given to both engineering and technology in the *Framework for K–12 Science Education,*[ii] on which the NGSS was based, lead to questions about the relationships and differences between STEM and NGSS. Is the NGSS really a set of STEM standards? To understand what makes the NGSS distinct in some important ways from STEM instruction, it is helpful to consider the rationales for these two important initiatives, and for science education more generally.

Ed Robeck serves as a consultant for McGraw-Hill Education, writing and reviewing labs and activities for various science programs. He is a professor of science education at Salisbury University, in Salisbury, MD. His work with children and teachers includes exploring the curriculum potential of household technologies, handicrafts, and everyday practices such as cooking and gardening. His interests also include the use of student-generated media as part of science instruction, encouraging citizen science projects in schools, and promoting environmental literacy through explorations of nature-oriented children's literature. Ed has conducted science teacher professional development nationally throughout the United States and internationally in India, the Philippines and elsewhere, including Malaysia where he was a Fulbright scholar in the spring of 2008. He teaches in both face-to-face and online formats to students at Salisbury University and the Open University of Malaysia. He works closely with teachers in local school systems in the implementation of innovative practices, including those promoted by the Next Generation Science Standards.

The impetus for including integrated STEM instruction in preK–12 classrooms and in higher education is largely justified by a workforce imperative.[iii] That is, there is great concern that in the United States, not enough young people are being trained in STEM fields such as engineering, computer science, geoscience, electronics, and so on, to replace the current workers in those fields who are going to be retiring relatively soon, or to address the increased need for such workers that will come about as societies depend increasingly on emerging and sophisticated technologies. In addition, STEM education is seen as a vehicle by which the United States will continue to be at the forefront of technological innovation, especially in ways that enhance economic opportunities, improve the quality of life, and address environmental challenges. As a result, STEM education initiatives have led to many networks and partnerships among industry, education, and government, such as those promoted by President Obama's "Educate to Innovate" campaign,[iv] and others.[v] To address the need for STEM specialists, preK–12 educators are being asked to identify learners who are talented and motivated in these fields, as well as others who could be, and to nurture their interests related to STEM generally and in specific STEM fields that each learner finds enticing.[vi] While it is definitely the case that there are other rationales for promoting STEM programs in schools, much of the justification for STEM education ultimately ties back to this workforce-related rationale.

STEM education encourages exploration and problem solving in ways that apply, create, assess, and adjust technologies through activities that are intended to be as authentic as possible. Many STEM activities involve students in designing and building structures and products, so that they can feel the sense of accomplishment that comes from applying knowledge and skills to solve problems. In such activities, STEM instruction often draws from one of the many representations of engineering and design processes, or engineering design cycles, which are followed more or less closely by professional STEM workers.[vii] As a result of STEM activities, many students have recognized that they have an interest in STEM fields. Further, in some cases, students realize that STEM fields are far more creative than they had envisioned them to be. This emphasis on the creative dimension of STEM instruction has led some to advocate for it to be thought of as STEAM instruction,[viii] where the "A" gives attention to the potential brought in by including dimensions of the creative arts.

While the NGSS is intended to promote science and engineering practices and career choices, it is also intended to educate learners for civic engagement and personal fulfillment. For example, the NGSS website states that what NGSS calls *disciplinary core ideas*, "…relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge."[ix] In short, whereas STEM instruction places priority on identifying and nurturing a subset of abilities and purposes addressed by science education, NGSS has a mandate to enhance the science literacy of all students, and for many purposes, which include those of STEM instruction, but also go beyond them. This difference in focus affects the nature of the experiences children need to have.

While STEM activities usually focus on aspects of the designed world as a starting and/or endpoint, the NGSS promotes experiences that may have as their primary concern, concepts and principles of how natural laws operate in systems that are not being directly manipulated by people. Systems that operate outside of direct human intervention are as much a part of NGSS instruction as are those designed and manipulated by people. So, whereas understanding the physical structures that allow most birds to fly could itself be the central focus of a lesson addressing NGSS performance expectations (e.g., 4-LS1-1), in a STEM lesson that topic would typically be taken further to consider how knowledge of such biological structures can be used in engineering applications. Yet, within the NGSS, too, there is the opportunity for students to consider the interplay of the natural world and designed systems, such as by considering how the structures of living things can be used to solve human problems (e.g., 1-LS1-1). In this way, the NGSS and STEM initiatives are in harmony with each other.

The different emphases of STEM and NGSS are definitely complementary and, depending on how they are implemented, they have the potential to intersect each other at several points. Understanding how physical laws operate is essential for understanding how the designed world works. Bridges, clothes, pencils, computers, and other technologies all operate through principles that define the interactions of forces, energy, and matter. Understanding how designed systems affect other aspects of the world depends on such fundamental knowledge that comes from basic science. While STEM instruction may begin with a focus on the designed world, a full understanding of the designed world depends on also understanding systems that have not been altered by people—what are sometimes called natural systems (though that can beg arguments about what is and is not natural[x]). Similarly, while the NGSS includes aspects of basic science that are relevant outside of engineering and design processes, it also promotes an understanding of those processes and practices even among students who are not going to take part in science or engineering professionally.

The NGSS promote a form of science literacy that includes an appreciation of the importance of understanding not only how the natural world works, but how the natural world interfaces with the designed world—how the natural world and the designed world affect and are affected by each other. In addition, the NGSS strives to encourage science education that also helps learners to develop knowledge of the processes by which the natural world is studied and how the designed world comes into being through the work done by engineers, technicians, and others. It is not enough, for example, for children to understand how a light bulb lights; they need also to understand how the light bulb came to be, how it has changed over time, and the impact its use has on other parts of the world, such as the environment. The NGSS offers, therefore, an approach to science education that is not only very inclusive in terms of the students it intends to reach, but also in terms of the purposes it intends to serve for learners and society. The NGSS suggests a vision in which the general public understands the ideas of science, the impact of science, and how both scientific investigations and engineering processes are carried out. It is a vision in which members of society become fully prepared to address the challenges and opportunities of the future.

[i] Achieve, Inc. (2013). *Next Generation Science Standards.* http://www.nextgenscience.org/next-generation-science-standards

[ii] National Research Council (NRC). (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

[iii] For example, see: U.S. Congress Joint Economic Committee, (April 2012). *STEM Education: Preparing for the Jobs of the Future.* http://www.jec.senate.gov/public/index.cfm?a=Files.Serve&File_id=6aaa7e1f-9586-47be-82e7-326f47658320

[iv] White House press release, "President Obama Launches 'Educate to Innovate' Campaign for Excellence in Science, Technology, Engineering & Math (Stem) Education," November 23, 2009. http://www.whitehouse.gov/the-press-office/president-obama-launches-educate-innovate-campaign-excellence-science-technology-en

[v] For example, see: Inspire STEM USA http://inspirestemusa.org/

[vi] Subotnik, R., Orland, M., Rayhack, K., Schuck, J., Edmiston, A., Earle, J., … Fuchs, B. (2009). Identifying and developing talent in science, technology, engineering, and mathematics (STEM): An agenda for research, policy, and practice. In Larisa V. Shavinina (Ed.), *International Handbook on Giftedness* (pp. 1313–1326). New York, NY: Springer.

[vii] For example, see: NASA Engineering Design Process. http://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html

[viii] Beal, S. (2013, August 30). Turn STEM to STEAM: Why science needs the arts. *Huffington Post.* Retrieved from: http://www.huffingtonpost.com/stephen-beal/turn-stem-to-steam_b_3424356.html

[ix] For example, see: http://www.nextgenscience.org/three-dimensions

[x] For example, see: http://undsci.berkeley.edu/article/natural