Integrating Engineering Into the Next Generation Science Standards

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There has been much talk regarding the inclusion of “engineering” in the Next Generation Science Standards (NGSS) (Achieve 2013). Are we being asked to do more now than the basic content areas of life, earth and space, and physical science? Or, is the understanding of engineering related to the understanding of science? How will engineering concepts influence the teaching of science in the elementary school?

Actually, the inclusion of engineering constructs is not a totally new idea. After the Russians launched *Sputnik* in 1957 there was great concern that we were not producing enough scientists and engineers with our current school science curriculum. A period of federally funded science curriculum development quickly ensued. In the early 1980s, when foreign products, especially automobiles from Japan, began to out compete domestic products, there was another hue and cry for improved science and technology education. Project 2061 under the aegis of the American Association for the Advancement of Science (AAAS) concerned itself with scientific literacy for all American citizens. So named for the year Halley’s Comet will return to Earth,

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Project 2061 listed benchmarks of what all citizens should know by that time. One quote, now twenty years old, spoke to the need for the integration of science, mathematics, and technology and predicted the current concern for teaching students in the STEM (science, technology, engineering, and mathematics) disciplines:

> The terms and circumstances of human existence can be expected to change radically during the next human life span. Science, mathematics, and technology will be at the center of that change—causing it, shaping it, responding to it. Therefore, they will be essential to the education of today's children for tomorrow's world (AAAS 1993, p. xi).

At this point, let's stop and define what we mean by science, technology, and engineering. Then we will turn to how the three are interconnected and are essential to a thorough education in science. Science is the knowledge of the natural world and how it works and also the practices that facilitate the discovery of these understandings. In *A Framework for K–12 Science Education,* engineering is defined as "a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants" (NRC 2012, p. 202). Technology is the product of these engineering efforts. That is, engineering is the process of designing a solution that meets some human need and that solution is technology—"technologies result when engineers apply their understanding of the natural world and of human behavior to design ways to satisfy human needs and wants" (NRC 2012, p. 12). While science deals with the natural world, engineering and technology deal with the designed world. Everything we encounter is in one of just three worlds, the natural, the social, and the designed and everything in the designed world has to be engineered by someone!

Science and technology are intimately interconnected. Some might argue that one depends on the other. There are many examples of science enlightening some new technologies and then the development of technologies leading to new discoveries in science. Consider how the basic understanding of light and its refraction through lenses led to the technology of microscopes and telescopes, which, of course led to countless new scientific discoveries. The same can be said for computers and many other technologies used by scientists.

It is because of this interconnectedness that engineering core ideas and practices have been included in the NGSS. To fully appreciate how science impacts our lives, it is important for children to understand this integration as well. In fact, the writers of *A Framework for K–12 Science Education* note, "We are convinced that engagement in the practices of engineering design is as much a part of learning science as engagement in the practices of science" (NRC 2012, p. 12). To that end, the practices of science and engineering are nearly identical with just two differences. While the practice of science begins by asking questions, engineering begins by defining a problem. Further, we do science in order to construct explanations (to answer our questions) but we engage in engineering in order to design solutions (to solve our defined problems).

The other practices for science and engineering are identical—developing and using models, planning and carrying out investigations, analyzing and interpreting data, engaging in argument from evidence, and obtaining, evaluating, and communicating information. These are the practices we must both employ and understand to engage in science and engineering.

How will this all play out in the classroom? Consider the engineering and design performance expectations for Grades 3–5.

3-5.Engineering Design	
Students who demonstrate understanding can:	
3-5-ETS1-1.	**Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.**
3-5-ETS1-2.	**Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**
3-5-ETS1-3.	**Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**

Here students are to define a simple design problem that includes specified criteria for success with constraints as to materials, time, and/or cost. They then are to generate possible solutions to meet these criteria and constraints and plan and carry out fair tests of the different designs in which variables are controlled. A favorite activity is to have students design life preservers (Moyer and Everett, 2012) that will keep plastic action figures (toy soldiers) floating with their faces out of the water. Additional constraints might be to minimize the amount of floatation material or to maximize potential movement while wearing the life preserver. Qualitatively, students will discover that if you increase the volume of an object without adding too much mass, you can make virtually any object float. This simple lesson combines the engineering design of a piece of technology with the science concept of sinking and floating.

The addition of engineering design and engineering practices to the standards in a more integrated way than in the past should help teachers and children develop understandings about how science and engineering are interconnected. Engineering and science have, in a sense, a symbiotic relationship, evolving together—they should be taught together as well.

Resources:

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

American Association for the Advancement of Science (AAAS). (1993). Benchmarks for science literacy. New York: Oxford University Press.

Moyer, R. & Everett, S. (2012). Everyday engineering: Putting the E in STEM teaching and learning. Arlington, VA: NSTA Press.

National Research Council (NRC). (1996). National science education standards. Washington, DC: National Academy Press.

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