The "Missing" Core Idea

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Over his career, Cary has directed more than 20 state and federal grant projects, including several that involved the development and testing of new curricula and methods of assessment.

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (NRC, 2012) proposed thirteen core ideas that all students are expected to learn, at increasing levels of sophistication and mastery as they ascend the grade levels from kindergarten through senior year of high school. The *Next Generation Science Standards* (NGSS Lead States, 2013) were faithfully built on the foundation of the *Framework,* incorporating not only the core ideas, but also integrating them with science and engineering practices and crosscutting concepts.

However, the NGSS included just twelve core ideas—not thirteen. So as not to keep the reader in suspense unnecessarily, I will reveal that core idea is "Links among engineering, technology, science, and society." In my view, this is one of the most important—perhaps *the* most important—idea that we want our students to understand as they take on adult responsibilities. Why then, was it left out?

Well, it wasn't actually left out of the NGSS. It is included as a crosscutting concept rather than a core idea. It is also not a single idea, but rather two distinct ideas about the interrelationship of engineering, technology, and science on the one hand, and society and the environment on the other. To better understand these core ideas, let's take a closer look at how they appear in the *Framework.*

For each core idea the *Framework* identified an essential question. In this case the question was, "How are engineering, technology, science, and society interrelated?" The *Framework* provided two answers to the question.

First answer: Science, engineering, and technology are interdependent.

> *The fields of science and engineering are mutually supportive, and scientists and engineers often work together in teams, especially in fields at the borders of science and engineering. Advances in science offer new capabilities, new materials, or new understanding of processes that can be applied through engineering to produce advances in technology. Advances in technology, in turn,*

> *provide scientists with new capabilities to probe the natural world at larger or smaller scales; to record, manage, and analyze data; and to model ever more complex systems with greater precision. In addition, engineers' efforts to develop or improve technologies often raise new questions for scientists' investigations.* (NRC, 2012, p. 203)

It seemed to the writing team that the best way to communicate this important idea was through examples illustrating how science and engineering are a "two-way street," with technology squarely in the middle. For instance, scientists are unable to learn about the nature of sound, light, and radio waves without instruments (technologies) designed by engineers, while engineers are unable to construct communications devices such as telephones and televisions (also technologies) without a scientific understanding of wave phenomena. Consequently, references to the "Interdependence of science, engineering, and technology" appear in the crosscutting concept box on quite a few of the standards, indicating opportunities to teach this important idea in the context of a specific scientific idea, field of engineering, and set of technologies.

Second answer: Science, engineering, and technology influence society and the environment.

> *Together, advances in science, engineering, and technology can have—and indeed have had—profound effects on human society, in such areas as agriculture, transportation, health care, and communication, and on the natural environment. Each system can change significantly when new technologies are introduced, with both desired effects and unexpected outcomes.* (NRC, 2012, p. 210).

This idea is also a "two-way street." The idea that scientific discoveries and technological decisions affect human society and the natural environment is rather well known. The other side of the coin is that people make decisions that ultimately guide the work of scientists and engineers. The *Framework* states the following:

> *Not only do science and engineering affect society, society's decisions (whether made through market forces or political processes) influence the work of scientists and engineers. These decisions sometimes establish goals and priorities for improving or replacing technologies; at other times they set limits, such as in regulating the extraction of raw materials or in setting allowable levels of pollution from mining, farming, and industry.* (NRC, 2012, p. 212)

How do these ideas play out in the curriculum?

Consider the following performance expectations from the NGSS that lend themselves to presenting these larger ideas.

1st grade: 1-PS4-1. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

> **Example of interdependence:** The science of sound helps people design musical instruments and other sound devices, while instruments that measure and amplify sound, such as a doctor's stethoscope, help people learn about the world around them.

2nd grade: 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

> **Example of influence:** The investigation of material properties led to a wide variety of containers for things such as groceries that we needed to purchase and take home. Eventually, people's concerns about the vast amounts of waste from empty containers led scientists and engineers to find ways to recycle and reuse as many of these containers as possible.

3rd grade: 3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.

> **Example of interdependence:** The discovery of magnetism led to the invention of the compass that people could use to find their way on land and sea. The use of compasses led to the discovery that Earth itself is a huge magnet.

4th grade: 4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

> **Example of influence:** The growth in the number of automobiles over the past 50 years has had a significant impact on the environment. People's concerns about such issues as air pollution and oil spills have led scientists and engineers to develop alternative methods of obtaining and using energy.

5th grade: 5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

> **Example of interdependence:** By observing the Sun, Moon, and stars carefully over a very long time, people were able to use their growing knowledge of astronomy to create clocks and calendars. The use of clocks, calendars, and other instruments, such as telescopes, led to further understanding of Earth's place among the other planets, the Sun, Moon, and stars.

The two "missing" core ideas can be found throughout the NGSS, but you won't find

them unless you're looking for them. The interdependence of science and engineering is evident wherever scientists use instruments of any sort, and where engineers apply scientific ideas to solve problems and meet people's needs. The influence of engineering, technology, and science on society and the environment is implicit in every performance expectation concerning the impact of new discoveries and technologies, as well as in cases where societal concerns direct the work of scientists and engineers.

In a sense, the "missing" core ideas are hiding in plain sight. It's our job as teachers to call them out whenever we can, and to ask leading questions so that our students can begin to see how what they are doing in science class relates to the world around them.