ENGINEERING ESSENTIALS FOR STEM INSTRUCTION

How do I infuse real-world problem solving into science, technology, and math?

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Engineering and Its Role in STEM

Many educators today say that the traditional approach to teaching science, technology, engineering, and mathematics is outdated, and that the STEM subjects should be taught together rather than as totally separate, "siloed" disciplines. In this publication, we will look at how engineering, the "E" in STEM, can unify all four subject areas.

The best and most engaging way to achieve this unity is through engineering projects that ask students to design solutions for real-world problems. Consider that in the mathematics classroom, problem solving has long been promoted as the way for teachers and students to climb up the Bloom's taxonomy pyramid. Engineering projects steer students past simple questions of how many apples Sally has and toward authentic problem-solving situations. Whereas students in science class can sometimes get bogged down in following a series of steps to verify an accepted scientific fact, engineering projects open their eyes to the discipline's true nature. Projects that ask students to apply current knowledge and exploration to new areas in pursuit of the elusive "best" solution make them active players in the world of science. Finally, when students see technology through the lens of engineering, they understand that it's much more than a synonym for "something that can be plugged in." Engineering

both drives innovation of technology and uses technology to create advancements in the world around us.

What Is Engineering?

Before we consider how to introduce engineering into science, math, and technology instruction, there are some questions to be answered. Perhaps the most basic are "What is engineering?" and "What do engineers really do?"

Defining engineering and the work of engineers is somewhat like defining medicine and the work of those who practice it. In the field of medicine, there are surgeons, doctors, nurses, researchers, technicians, and many other kinds of workers. The challenge of coming up with a definition of what all these people do is compounded by the field's many branches—cardiology, dermatology, pediatrics, psychiatry, and so on. Still, it's a bit easier for us to grasp the "whole" of medicine because the average person actually comes in contact with doctors and nurses. We have the opportunity to talk to our X-ray technician, surgeon, pharmacist, or physical therapist. By comparison, very few of us will meet the civil engineer who designed the bridge we drive across on the way to work, or the chemical engineer who came up with the laundry detergent formula that makes our whites whiter.

A full examination of engineering and engineering education would require many more words than this format allows. But in the same way that a tourist heading to Paris can find in a Michelin guidebook ample information to make a stay in the City of Light more rewarding, in this publication's overview of engineering, you'll find guidance

to help you bring engineering into the classroom in a more meaningful way—and make a real, positive difference in your students' learning.

Let's begin our tour by looking at how engineering is generally defined. According to the *American Heritage Dictionary* (2009), *engineering* is "the application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems." Most general dictionaries define engineering similarly—as an application of math and science.

When we turn to the definitions offered by engineering-based groups, there's a definite shift toward a more specialized meaning. The American Society for Engineering Education produces a website and publication called *Engineering, Go For It,* or *eGFI* for short. (Available at www.egfi-k12.org, it is a great source for teachers and students interested in learning more about engineering fields.) In the October 2009 issue, *eGFI* states the following:

> Engineers solve problems using science and math, harnessing the forces and materials in nature. They draw on their creative powers to come up with quicker, better, and less expensive ways to do the things that need to be done. And they find ways to make dreams a reality. (p. 2)

The difference from the standard dictionary definition is subtle but important. In the *eGFI* definition, and for engineers, *solving problems* comes first. However, we want to

be careful not to translate this statement into something oversimplified, such as "to solve problems in math or science classrooms is to do engineering." After all, at one time it was popular to try to teach critical thinking skills by giving students word problems or story problems. The trouble was, these problems were often one-dimensional and had little relation to the world in which the students lived. Engineers derive the problems they tackle from the real world around them. Yes, in the classroom, for educational purposes, it is sometimes necessary that problems be "made up" rather than actual, but they should never be simplistic or irrelevant.

Tools for Engineering

Having established that solving problems is the main goal in engineering, the next question to consider is how engineers go about that work. As the statement in *eGFI* indicates, they make use of math and science. In fairness to the "T" in STEM, they also make use of technology. But math, science, and technology are only some of the tools that engineers use. Depending on the field of engineering, an engineer's toolbox can be filled with a tremendous assortment of methods to solve whatever problem is on the table. Let's look at the most common tools at an engineer's disposal.

Engineers generally have and need inherent *curiosity.* When I worked in a public engineering high school that had no entrance requirements, one of our principals advocated evaluating prospective students' suitability for the program by asking them if they were good in math and science. I told the principal that it would be better to ask students if they