

## **A Little Separation, Please**

**Arthur T. Johnson**

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It has become popular to combine Science, Technology, Engineering, and Mathematics into the acronym STEM when discussing education. But, as an engineer, I have some difficulty with STEM. Science requires curiosity for new knowledge, technology requires skill, mathematics requires logic, but engineering requires creativity and judgment. Engineering, to be sure, requires science, technology, and mathematics (STM) as tools to assure that a design will be successful, but the first step in the design process is invention – the critical beginning of a new idea. In this respect, engineering is different from STM.

As a child, I had many interests, and dreamed that someday I would become either a scientist or an artist. That dream persisted until high school, when I learned about engineering. The path that I chose combined both of my passions into one profession.

The humanitarian and artistic side of engineering is often downplayed, if not ignored, in engineering education. Engineering science courses, essentially applied physics, use mathematical tools almost exclusively to solve problems. These engineering science courses give nascent engineers the technological skills to analyze a trial design to assess likelihood of success. But the design process involves synthesis as well as analysis, and the synthesis part of this process is not given the same attention as the analysis part. We engineering educators depend very much on the native creativity of our students to be able to synthesize.

Along with synthesis, engineers must learn judgment: how to go about the process of determining whether or not a new concept will work, often before the mathematical analysis stage. Judgment requires experience, and experience usually involves failure on somebody's part. If that failure does not happen in school, where its consequences are limited, then that failure, and its accompanying experience and growth of engineering judgment has to be developed in the workplace. That is why employers of just-graduated engineers often give their new employees mentored dummy projects to work on during the first six months of their tenure. An engineer who has not developed engineering judgment by that time is either not retained or faces potentially more catastrophic failure later in her/his career.

The Accreditation Board for Engineering and Technology (ABET) requires the inclusion of humanities courses in engineering curricula. The reason is clear: engineers often need to include non-scientific, non-mathematical, even non-technological features in their designs. There are artistic, historical, political, psychological, financial, spatial, and other elements that must be

considered for a prototype engineering design to be successful. There have been many examples of new products that have failed because they didn't look right, were named wrong, didn't feel right, or were too complicated. All of these fit into the category of engineering judgment.

The reason that the "E" in STEM should be distinguished from the STM part is that engineering can appeal to those who are not so good at STM, but who have superior skills or interest in the softer side of engineering. They can become great patent lawyers, engineering managers, recruiters, teachers, insurance adjusters, human factors engineers, or sales/applications engineers. Some engineering disciplines are more people-oriented than others. I have had "C" students in my Transport Processes and Electronic Design classes who could talk a lawyer into the ground. With the technical backgrounds that they had barely mastered, they used the softer skills in which they excelled to find successful careers on the fringes of engineering. We need these kinds of people, too.

The American Association of University Women has a 2010 report entitled *Why so Few? Women in Science, Technology, Engineering, and Mathematics*, in which they deplore the fact that it is difficult to attract young women into STEM fields. One reason they give for this is the stronger interest young women have in people and interpersonal relationships that are not usually associated with STEM fields. But, if it were better known that engineers do not have to be nerds and recluses, that as engineers they could have a rich involvement with other people, then the "E" part of STEM might attract more women and men to the profession. This is the problem with the acronym STEM; it does not do justice to the full range of opportunities available in engineering.