InFocus

thoughts from a member of the Editorial Board

Engineering Knowledge

By Jon A. Schmidt, P.E., SECB

I have written previously about the fact that the scientific method is well-known to the general public, while the engineering method is little-known even among those of us who practice the engineering profession. This is at least partially a consequence of the fact that the philosophy of science has been an academic discipline for many decades, while the philosophy of engineering has only emerged as a subject of serious inquiry much more recently.

The philosophy of engineering is often identified with, or treated as a branch of, the philosophy of technology. As a structural engineer, I do not tend to think of the fruits of my labor as being "technology"; that term seems to refer more naturally to the tools that I use to do my job – computers, software, printers, copiers, fax machines, cell phones, etc. However, *Merriam Webster's Collegiate Dictionary*, 10th Edition, defines technology as "the practical application of knowledge, especially in a particular area; a capability given by the practical application of knowledge; [or] a manner of accomplishing a task, especially using technical processes, methods, or knowledge."

Notice that the one word common to all three definitions is *knowledge*, and that the first two both incorporate its *practical application*. It is not surprising, then, that much of the discussion about the philosophy of technology tends to delve into epistemology, which is defined as "the study or a theory of the nature and grounds of knowledge, especially with reference to its limits and validity."

Joseph C. Pitt, a professor of philosophy at Virginia Tech, wrote an article in 2001 entitled, "What Engineers Know" (**http://scholar.lib.vt.edu/ejournals/SPT/v5n3/pdf/pitt.pdf**). He compared scientific knowledge with engineering knowledge and came to the somewhat surprising conclusion that the latter is more reliable than the former. The two key features of scientific knowledge are that it is "theory-bound" and has explanation as its ultimate aim, which means that it is always provisional and may be modified or overturned by new evidence. By contrast, engineering knowledge is "task-specific and aims at the production of an artifact to serve a predetermined purpose," with the result that it can usually be documented and referenced when needed again in the future.

We tend to view the concept of "cookbook engineering" unfavorably, because it seems to remove the need for experience and judgment. However, Pitt points out that "a good cookbook providing stress calculations can be used anywhere, anytime, as long as you factor in the appropriate contingencies." Recognizing and accounting for "the appropriate contingencies" is precisely where experience and judgment are essential. Most people can follow a recipe to prepare a good meal, but that is not enough to make them all into master chefs.

This brings me back to two key definitions from Billy Vaughn Koen's book, *Discussion of the Method*:

- The engineering method is the use of *heuristics* to cause the best change in a poorly understood situation within the available resources.
- A *heuristic* is anything that provides a plausible aid or direction in the solution of a problem but is in the final analysis unjustified, incapable of justification, and potentially fallible.

How is it possible for admittedly "unjustified" and "fallible" tools to produce a more reliable form of knowledge than that obtained by scientific means, which are so highly esteemed by our culture? The primary criterion for selecting and applying heuristics in a particular situation is the fact that they have worked in the past – which happens to be the very same empirical and inductive basis that underlies all scientific theories. However, the goal of engineering knowledge is more modest than that of scientific knowledge – "knowing how" to accomplish something, as opposed to "knowing that" the universe operates in a particular way. As long as the task to be performed is substantially the same, the heuristic that did the job last time is bound to be successful again.

The bottom line is that all knowledge is ultimately faith-based. We "know" that the earth rotates on its axis and revolves around the sun, not because we have observed these behaviors ourselves – after all, we still talk about the sun rising and setting - but because scientists assure us that predictions derived from such concepts are consistently accurate. We "know" that a ¾-inch diameter ASTM A325 bolt in single shear with threads excluded from the shear plane has a nominal strength of 15.9 kips, not because we have tested every such bolt ourselves – or even just the ones for our own projects – but because the AISC *Manual of Steel Construction* tells us so.

In other words, neither scientific knowledge nor engineering knowledge can be equated with certainty. Theories and models are not facts, no matter how sophisticated they become. Consequently, I believe that the best engineers are the ones who are the most aware of the limits of their knowledge.▪

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