The Engineering Way of Thinking: The Future

By William M. Bulleit, Ph.D., P.E.

As discussed previously in this space (*The Engineering Way of Thinking: The Idea*, STRUCTURE December 2015), engineering is continually evolving as engineers try new tools, develop new designs, and build new or modified artifacts. All of these expand the heuristics that engineers use, but many times lead to failures. Henry Petroski has even argued that engineering advances through failures.

The engineering way of thinking (EWT) accepts the inevitability of failures because heuristics always have limits, and trying new tools and building new artifacts always pushes these limits. It is not feasible to wait until all scientific knowledge about whatever is being designed becomes available, since nothing would ever get done. Science is never done; there is always more to know.

The inevitability of failures causes engineers to be conservative about change. Engineers know that change is essential to the evolution of their profession and society; they also know that today's heuristics have limits, and exceeding those limits can cause failures. Thus change must consider not only how we can advance engineering, but what the potential consequences are. The inability of engineers to imagine and predict such consequences has caused some to believe that today's environmental and societal problems are due largely to engineers and engineering.

I suggest that the real problem is a society, including its engineers, that has not followed the EWT. People in general, and engineers in particular, have allowed themselves to get trapped in a narrow conception of what engineering should entail. Engineering needs to be perturbed; we need to use the EWT to re-engineer engineering.

Stephen Goldman has argued that engineers are socially captive – working for owners, firms, and others such that they just want to get a job done and not think beyond that. To a great extent, this is true – and it will always be true as long as engineers make a living doing engineering. Given that limitation, what can we do to get engineers to use the EWT more broadly?

First, even the most socially captive engineer works with documents developed by the engineering community: regulations, codes of practice, design guides, textbooks, and other compilations of engineering knowledge, each developed by individual engineers or groups of engineers. These individuals and groups are in a position to begin using the EWT in a broader context to perturb engineering. In the long run, even the socially captive engineer will then need to change in order to work within the updated system. However, the EWT is not dependent on any engineering discipline, individual engineer, or group of engineers.

With apologies to philosopher Wilfrid Sellars, the EWT is a means to approach design, in the broadest possible sense of the term, using heuristics, in the broadest possible sense of the term, to develop artifacts, in the broadest possible sense of the term. The design needs to include as much of the system in which the artifact resides as is practical, based on the heuristics available to the engineer at the point in time when the design is being performed. Furthermore, the EWT must evolve as the available heuristics change to meet the demands of a constantly changing society. In fact, the EWT should be used to help engineer society.

This is not about how engineering was used to attempt to change society in the past, particularly some of the nearsighted efforts of the mid-20th century. These merely employed the engineering of the time, not the EWT; and we seem to be making the same kinds of mistakes today. The blame resides with not only engineers, but also among others, politicians, voters, teachers, and colleges and universities (including engineering schools). Therefore, rather than engineering society, we should talk about "*an* engineering society": a society that respects and uses the EWT in all its aspects. This is admittedly a radical suggestion, but only because the EWT has not been properly understood, even by engineers themselves.

What might this wide use of the EWT mean for engineers and society?

First, it would require engineers to broaden their horizons and develop mental models based on a wide range of disciplines. This idea is already being suggested by ASCE in its push for a broader undergraduate education and specialization at the graduate level. However, I would argue that the liberal undergraduate degree followed by engineering graduate school – modeled on law and medicine – is not the way to go.

The EWT requires a broad range of knowledge, with engineering deeply embedded in the other disciplines studied. To work toward better understanding of the EWT, we need an education that covers a fairly wide range of topics, but always keeps in mind how those topics will be used. Early engineering education needs to include subjects that have clear applications, even if they are not put to those exact uses when taught; mathematics is an obvious example. To suggest that non-engineering courses should come first, and then engineering later, is to build a structure that goes against the EWT.

Second, it would mean that non-engineering majors in universities would need to take some engineering courses as part of their general education – much like engineers take humanities and social sciences as part of their general education. Engineers recognize, sometimes begrudgingly, the importance of non-engineering knowledge; the converse is typically not true.

The EWT is somewhat alien to many, perhaps most, engineers; but we realize that when confronted with a new problem, we will think broadly enough to determine what heuristics, new or old, we need to solve it. This is really nothing but a limited version of the EWT. In my next article, I will analyze the EWT with the aim of convincing you further that engineering is broader than we have allowed ourselves to recognize.▪

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