Technically, I am a ... by Mark Raleigh

Are you a scientist or are you an engineer?

This seemingly straightforward question of professional identity is one that has occupied my mind for some time now. For me, the answer is complicated because my training and experience straddles both technical realms. All of my degrees are in Civil Engineering. Nevertheless, two of these are designated as “science” degrees (BS and MS degrees). I spent my first two years out of college working at an engineering firm designing flood control infrastructure, but over the last seven years have been engaged in hydrologic research that has little to do with the built environment.

Earlier this year I spent many hours studying for an exam to become a licensed Professional Engineer (PE) in Colorado. I soon found myself explaining to many science colleagues at NCAR what the PE exam was and why I was taking it (something I would never have to explain to an engineer). Upon passing the exam and celebrating with my engineering consulting colleagues, I found myself explaining to them my scientific research at NCAR and why I was doing it. This juxtaposition brought on a peculiar sense that I was treading in a gray area where neither the engineering camp nor the science camp recognized me as their own.

The feeling of estrangement has led me back to the basics. It has prompted me to consider the role of scientists and engineers in the world, how they think, and how they answer questions.
Many respected intellectuals, including Albert Einstein and Theodore von Kármán, have offered a simplified characterization of the distinct roles of scientists and engineers. To paraphrase, they agree that “scientists discover that which exists, while engineers create that which never existed before.” If we then imagine caricatures of the two professionals, we might say that “pure” scientists position themselves at the frontiers of knowledge with a trajectory toward the unknown, while engineers tend to stay within the realm of what is already known, adding value to this knowledge by applying it in concrete (and possibly new) ways to address societal needs and problems. Scientists are discoverers while engineers are the ambassadors between scientific knowledge and human needs.

Given the above idealization, it follows that there should be identifiable distinctions between how these caricatured scientists and engineers think. Certainly, their treatment of uncertainty is one of the delineating factors. It seems that scientists are in a position where it is more acceptable to include uncertainty in an answer (while recognizing the importance of minimizing the uncertainty). They might tell the public and policy makers that “sea level will increase X to Y m due to climate change.” In contrast, an engineer should factor in these levels of uncertainty but must provide a single answer in the design process. A seawall can only be built to a single height (Z m high) to adapt to the effects of X to Y m of sea level rise. So scientists can be more explicit about uncertainty in their experiments, whereas engineers are implicit about it in their designs (often through safety factors and risk analysis).

Interestingly, it seems there is a divide in how scientists and engineers arrive at the answer to questions posed to them. In science, there is often a most correct explanation for a natural phenomenon (possible exception: quantum mechanics and Schrödinger’s cat). Seasons are caused by the earth’s tilt, not by other factors such as the orbital proximity to the sun. However in engineering, there can be multiple “correct” solutions to a problem. Multiple solutions can be considered for building a road between two towns with a mountain range between them: a tunnel, a mountain pass, or a long road that goes around the range.

In my field of hydrology, we often run into this issue when calibrating hydrologic models to represent watershed processes such as streamflow. “Equifinality”, a term coined originally by a German biologist, Hans Driesch, and applied later to hydrologic modeling research by Keith Beven and Andrew Binley in 1992, describes the situation where essentially the same answer can be achieved with different model parameters. Equifinality is highly relevant to the divide between scientists and engineers as both may react differently to it. A scientific hydrologist looks at equifinality, shakes her head, and laments that the “right answer” is likely derived for the “wrong reasons” (i.e., the processes leading to the answer are likely wrong in many cases). On the other hand, an engineering hydrologist may not necessarily cringe at equifinality in a model, so long as the model yields the “right answer” under a wide variety of possible conditions. To the engineer, it may not matter whether the model pins down all of the underlying mechanisms of a flood, so long as the flood characteristics (e.g., flow, stage) most relevant to design considerations are accurately represented. A pure engineer might even argue that too many of the physical parameters of the system are unknown (and in some cases unknowable) and...
that the system is indeterminate; in these cases, engineering logic dictates that conservative estimates govern the design.

So it remains that scientists and engineers serve different functions and approach physical problems differently. As for me, I find that the haze surrounding my professional identity may stem from the fact that I have oscillated between the different perspectives offered by both professions. In the last ten years, I have applied the scientific method and the engineering design process in very different circumstances; I have considered myself both a discoverer and a creator. Perhaps it is possible, natural even, to have a career identity that has an intrinsic duality in the engineering-science realm. This suggests that the conception of engineering and science as a 1-dimensional, linear continuum is too simplistic, as is the assertion that engineering is merely a subset of science. In fact, Henry Petroski in 2010 suggested that the “axes” of engineering and science are actually orthogonal to each other. He argues that most professionals in this realm exhibit some characteristics of both identities, and that one’s place in this coordinate system may change over both short and long time scales. Given this perspective, it might be argued that there are few “pure” engineers and “pure” scientists, and that many technical professionals could be broadly classified as either “applied scientists” or “research engineers”, an amalgamation of engineer and scientist. Many factors may have increased the dimensionality of this professional identity system, such as engineering graduate programs focusing more on scientific research, and scientific funding agencies calling for research with more tangible benefits to society.

Thinking about your educational background, your technical training, and your research, where do you fall in the engineer-scientist coordinate system? I believe reflection on this question is important because it provides perspective about your place in the human-technological system. It also is useful for understanding how you think about problems differently from colleagues and how that influences your communication and collaboration.

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These are Boulder temperatures recorded by CGD Software Engineer Gary Strand at his home during our record-breaking cold of last week. As Gary put it, “The temperatures have fallen and they can’t get up!” Let’s hope we’re done with record-setting lows for this winter.