Some Thoughts on Engineering as a Humanistic Discipline*

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This presentation began with a summary of some salient facts about public perceptions of the roles of engineers and engineering in the United States at the beginning of the 21st century. These facts were set within the context of a shared sense, at least by the participants in MDW IV, that the engineering educational enterprise is in need of reform:

- Reform of the education engineering enterprise is necessary, but it 'hasn't caught fire.' Faculty resistance seems to be the main impediment. The National Academy of Engineering (NAE) is trying to help, by legitimizing engineering educational activities. For example, engineering educators can now be elected to the NAE for educational contributions (not just research). In addition, the NAE now awards the Gordon Prize of $500,000 for innovation in teaching (alongside the Russ and Draper prizes for engineering research).
- The NAE is an honorific organization that by its charter is also charged to provide advice to the nation on issues of science and technology. The NAE's approach has traditionally been passive, with the NAE responding when asked—but the new NAE strategic plan calls for it to be more proactive.
- Public policymakers are dangerously ignorant about engineering and technology. There are only six (6) engineers in the US congress—just 1%! Four of the six also have law degrees.
- While it is true that scientists and engineers cannot be 'whole people' without being educated in the humanities, the arts and literature, it is also the case that no one can be 'whole' without a basic understanding of science and technology and engineering. Further, it is engineering faculty who bear the responsibility of *educating* liberally educated people.

Science is both a *body of knowledge* and a *process*—the scientific method. Unfortunately, science education is too often simply teaching the body of knowledge; for example, introductory courses in biology are often about memorizing a new vocabulary. The body of knowledge generally taught is largely irregular in most societal contexts.

As a result, the laity—the general population—are scientifically illiterate. They do not understand the standards for accumulating and evaluating evidence: creationism is a theory, but it is not a theory just like evolution, because there is a serious imbalance between the bodies of *evidence* that support these two theories.

Technology refers to a body of knowledge and to a set of artifacts (e.g. bridges, planes, and wireless phones). *Engineering* refers to the *processes* by which the body of technological knowledge and its concomitant artifacts are created. The public understands the engineering process no better than it does the accumulation of scientific evidence. For example, the public has an irrational fear of nuclear power. Engineers cannot explain nuclear power enough for a public that does not trust engineering processes. And we, as engineers, have not really tried!

The noted aerodynamicist Theodore von Karman observed that science is about understanding nature, about what is; engineering is about what has never been. It might also be said that *engineering is design under constraint*. Further, engineering is a *creative* activity, which is something that the public does not appreciate. A technologically literate public would understand the facts (the body of knowledge), the engineering process, *and* the commercial considerations involved in making products that people want to buy. Communicating this to the public is *our* job; that is, it is the responsibility of the engineering community.

This means that improving engineering education means more than improving the education of engineers alone. Engineering faculty are or ought to be responsible for the liberal education of every student on campus. Science and technology history are not found in history books, save for the standard negative stories (e.g. DDT, the atomic bomb). In fact, one rationale for teaching engineering in this context is that it is a process by which people try to make the world better.

Engineering *can* be taught to non-engineering students. Unlike science, most of the artifact-centered body of knowledge of technology is familiar: it includes everyday stuff about which people are already curious (again, pacemakers,

PDAs, CD burners). People care about these things. The commercial considerations are easy to motivate. But we must *focus on the process*. And we must explain the notions of systems and interdependencies. And we should explore the larger implications—beyond reiterating the second law of thermodynamics to explain the concept that nothing is perfectly (100%) efficient. This can set the stage for explaining choices and tradeoffs, risks and costs, and feedback and control.

George C. Bugliarello, the Chancellor of Brooklyn's Polytechnic University, noted in a recent issue of the magazine *Science, Technology and Society* that the two cultures delineated by author C. P. Snow, science and literature, are now *diverging*. The engineering community, and engineering educators in particular, must work to reverse this trend. We should offer some courses that are open to non-engineering majors. We should develop educational materials. (Perhaps we should think of 'Civ II' courses that explore the history of technology and the application of the engineering process.) And perhaps we should offer BA degrees that are not ABET-accredited, with different core requirements. But we certainly should do something!

William A. Wulf was elected President of the National Academy of Engineering (NAE) in 1997. The NAE and National Academy of Sciences operate under a congressional charter to provide advice to government on issues of science and engineering. Dr. Wulf is on leave from the University of Virginia, where he is a university Professor. His research spans computer architecture, computer security, programming languages, and optimizing compilers. Dr. Wulf was also Assistant Director of the National Science Foundation during 1988–90 (on leave from Virginia). Prior to joining Virginia, he founded a software company, Tartan Laboratories, based on research he did while on the faculty at Carnegie-Mellon University. In addition to his leadership role in the NAE, Dr. Wulf is a Fellow of the American Academy of Arts and Sciences, a Corresponding Member of the Academia Española De Ingeniera, and a Foreign Member of the Russian Academy of Sciences. He is also a Fellow of four professional societies: the ACM, the IEEE, the AAAS, and AWIS. Dr. Wulf is the author of over 100 papers and technical reports, has written three books, holds two US patents, and has supervised over 25 Ph.D.s in Computer Science.