Editorial

Collaboration Conundrum

Greg Pearson

There may be few other issues more important to technology education at this moment than the nature of the profession's relationship to engineering. Technology education has undergone a significant reshaping since the mid-1980s, particularly when the International Technology Education Association (ITEA) launched the field on a standards-based reform path in the early 1990s. The standards' vision for what students ought to know and be able to do in technology reflects a strong engineering influence. This is not surprising given that ITEA sought input from the National Academy of Engineering (NAE) on the standards and, later, submitted the standards to an intensive quality-review process at the National Research Council (NRC).

This editorial examines how engineering and technology education view one another, and how these perceptions shape prospects for collaboration between the two camps. These are important issues, though one could reasonably question my qualifications for addressing them. I am neither a technology educator nor an engineer. However, my work at the NAE has brought me in contact with many individuals from both groups. My lack of pedigree has allowed me to observe each at a certain distance. What follows is very much a personal take on the psychology and politics of the relationship between engineering and technology education.

No Respect

Rodney Dangerfield must have been an engineer before he went into comedy. No, wait. Maybe he was in technology education![1]

It is striking, and an interesting point of departure for this editorial, that both engineering and technology education believe themselves to be undervalued. Although these feelings find expression in different ways, they provide a common basis for strengthening ties between the two groups.

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It may come as a surprise to many technology educators that engineering has for years—decades, in fact—been engaged in a campaign for public recognition. Engineers in industry, academia, and public service, along with the professional societies that represent them, have met countless times and funded hundreds of public outreach efforts, all with the goal of improving the public image of engineering. The NAE and many professional engineering societies have programs dedicated to boosting public understanding of engineering (PUE). Results of a survey recently commissioned by the NAE indicate PUE efforts consume some $400 million per year in the United States (Davis & Gibbin, 2002). Despite this investment, most engineering groups believe the public neither understands nor appreciates sufficiently the role of engineering in society.

As one measure of standing, Harris Interactive tracks the prestige of various professional fields. In these polls, engineering consistently places in the top half of the 17 professions assessed. In the latest survey, only 5 other professions (policeman, minister, teacher, scientist, doctor) had a higher ranking of "very great" prestige than did engineering (Harris Interactive, 1998). Despite results that could be interpreted as quite encouraging, many in the engineering community perceive these findings as evidence of a failure to communicate its mission and accomplishments to the public. The fact that the public bestows scientists with almost twice the amount of prestige as engineers is particularly rankling. Engineers, it seems, just don't get no respect.

Engineers also believe that the public does not understand much about the role of engineering in society or what the practice of engineering involves. Some support for this view comes from a 1998 Louis Harris & Associates poll, commissioned by the American Association of Engineering Societies (AAES), that asked people to associate certain characteristics with either scientists or engineers. An overwhelming majority correctly associated scientists with "discovering the natural world" and engineers with "creating economic growth." However, compared with scientists, engineers were one-fourth as likely to be associated with "improving the quality of life" and only one-tenth as likely to be associated with "saving lives."[2] Harris Interactive (2004) recently released results from a follow-on survey, also sponsored by AAES. For the most part, engineering compared quite favorably to science; for example, both were seen as equally attractive potential careers for young people. So, while the public perception of engineering is not as informed as many within the profession would like, neither is it wholly negative or inaccurate.

Engineers are also frequently the focus of blame when technologies fail to perform as we expect. Engineering was very visible during the aftermath of 9-11, with the bulk of media coverage portraying the profession in a favorable light. Far more often when engineering is in the spotlight, however, engineers are portrayed as contributors to, if not the direct cause of, disaster (e.g., separation of Firestone tire treads, loss of Space Shuttles Challenger and Columbia, collapse of Hyatt Regency walkway). Adding insult to injury, credit for accomplishments such as the development and launch of the Hubble Space

Telescope that are mostly the result of engineering, frequently is assigned to science. This phenomenon reflects public confusion about how technology is developed as well as society's lack of appreciation for the inherent risk of technological development. It reinforces the engineering profession's "Dangerfield complex."

There are many explanations for why engineering is not well understood, but one of them certainly has to be the discipline's near absence in U.S. elementary and secondary classrooms. With a few notable exceptions like February's National Engineers Week (www.eweek.org), engineers rarely interact directly with K-12 teachers or students. Further, engineering concepts and design principles for the most part are not part of the regular school curriculum. The history and nature of "pre-engineering" in American K-12 schools have been examined by others (Lewis, 2002).

Technology education suffers its own image and identity problems. In contrast to engineering, technology education is embedded in the K-12 classroom. It is a profession of teaching, albeit comprising an order-of-magnitude smaller workforce than more mainstream subjects such as science and mathematics. In addition to its size disadvantage, the profession has had to struggle with its roots in the manual arts as it attempts a transition to a more academic and intellectually robust self-definition. ITEA's development of content standards and its efforts to align with engineering reflect a conscious striving for legitimacy within the landscape of U.S. education. Science education validates itself through science, and mathematics education through the work of mathematicians. Why not technology education through engineering?

Irrespective of the attempted makeover, most outside the profession, including many engineers, still see technology education through the lens of "shop class," a term almost always used pejoratively. Ironically, one growing concern in engineering education is the entering freshman's lack of hands-on, tool skills. This in part reflects the turning away of engineering schools, beginning at the end of World War II, from practice toward science, theory, and laboratory work (Davis, 1998). The estrangement of today's student engineer from the machine shop and field work has been accelerated by, among other things, the profession's reliance on computer-based design tools and the increasing complexity of many technologies, which has made tinkering seem unnecessary and, more to the point, impractical.

One continuing challenge to technology education's identity is of its own making. The profession's name change in 1985, from the American Industrial Arts Association to the International Technology Education Association, had the unintended effect of making it difficult for the field to differentiate itself from those engaged in the promotion of educational technology. As polling has shown, most Americans have a very narrow conception of technology, as information technology, especially computers (ITEA, 2002). What technology educator has not been confounded by the well-meaning misinterpretation of her occupation: "Oh, you teach computers!?"

I purposefully chose the pronoun “her” above because I knew it would be jarring to most readers in the profession. Women, of course, comprise only a small minority of those in technology education. Slightly fewer than 14 percent of ITEA members, most of whom are teachers, are women, membership data from 2000 indicate (S. Petrina, personal communication, February 27, 2004). Because only about one-sixth of all technology educators belong to ITEA, these numbers may not accurately reflect the diversity of the profession as a whole, but it would be surprising if they were significantly higher. The presence of underrepresented minorities is equally stark. In the early 1990s, about 1 percent of vocational technology teachers were Native American, 0.2 percent Asian, 6.7 percent African American, and 2.2 percent Hispanic (U.S. Department of Education, 1993).

Similarly, engineering remains one of the most disproportionately pale and male career fields. Underrepresented racial and ethnic minorities account for a quarter of the nation’s population and roughly a third of the overall U.S. workforce but less than 12 percent of BS, 6 percent of MS, and 4 percent of PhD engineering graduates, and 7 percent of the engineering workforce. Women constitute more than half the nation’s population and 60 percent of the workforce but less than 22 percent of engineering BS and MS graduates, 18 percent of engineering PhDs, and only 10 percent of the engineering workforce (Commission on Professionals in Science and Technology, 2002; National Science Board, 2002). (In the interest of full disclosure, women members of the NAE comprise only 3.4 percent of the total membership, a number in part explained by the scarcity of late-career women engineers in the population at large.) The engineering community is well aware of these imbalances in the profession, and there are many initiatives intended to remedy the situation, but progress has been slow.

As I hope this brief review indicates, engineers and technology educators, and their respective professions, share a number of basic characteristics and face a number of similar problems.

- Problem-/project-centered learning
- Buy-in to technological literacy vision
- Concern about the professional “pipeline”
- Desire to influence K-12 education
- Desire to be seen as more relevant
- Misunderstood by the public
- Undergoing change and evolution
- Longstanding diversity problem

These points of commonality may influence in a positive way the two groups’ willingness and ability to reach out to each other in collaborative effort.

Snobs and Dummies

Let’s face it, engineering is filled with elitists and technology education is for blue-collar academic washouts. In my discussions with technology educators and engineers about their colleagues on the other side of the fence, these sentiments surfaced repeatedly. Both points of view, of course, are stereotypes and so by definition are oversimplified and prejudicial. Stereotypes also contain kernels of truth. Some engineers no doubt have an inflated sense of self-importance, and some who pursue technology education do so because of its less "academic," more concrete approach to learning. Stereotypes maintain their currency only as long as they are unaltered by personal experiences and honest self-reflection. If engineers and technology educators are to work together in a meaningful way, they surely will need to spend more time getting to know one another.

Much is made by both engineers and technology educators of the role mathematics and science play as enablers to the study and practice of engineering. Technology educators to whom I spoke returned again and again to this issue, contrasting engineering's focus on scientific theory and mathematical analysis with their field's emphasis on practical problem solving. The U.S. engineering education community traditionally has treated mathematics and science as barriers that only the most qualified students will overcome. It is thus common in many engineering schools for students to have no exposure to hands-on, engineering design problems until their sophomore year.

The academic hazing works. Nationally, over half of all students who start engineering school switch to degree programs outside of science, mathematics, engineering, and technology (Seymour & Hewitt, 1997). Some who leave do so because of poor academic performance, but a significant number, proportionately as many as whom actually graduate, perform as well as, on average, those who stay. It turns out that the most important factor for "switchers" is not inadequate preparation or the appeal of non-engineering fields, but rather poor teaching and advising (Seymour, 2001). A number of leaders in engineering education believe it is the profession's weak pedagogy and failure to present its creative side to prospective engineers that is to blame for the field's relative lack of popularity among young people.

A small number of U.S. engineering programs, including those at Tufts, the University of Maine, and the University of Colorado, are delaying intensive math and science coursework to the second year and are instead exposing freshmen to engaging design activities. At Tufts, this approach has resulted in a net flow of students from other university departments *into* engineering.

Could it be that design and problem-solving activities provide meaningful context for learning in math and science? This is certainly the claim of technology educators, but rarely if ever is the assertion made by engineering. Considerable educational research supports the value of learning experiences that students perceive to be relevant to their own lives. Several small studies of integrated math-science-technology curricula suggest such programs can boost math and science achievement more than when those two subjects are taught independently (Loepp, Meier, & Satchwell, 2000; Todd & Hutchinson, 2000). More research is needed to confirm these preliminary findings and to explore the context-setting influence of engineering and technology education on student learning in math and science.

Several engineers I spoke with, including Bill Wulf, president of the NAE, suggested that much quality engineering can be done with just algebra, and even students without high school calculus, chemistry, and physics can learn the math and science concepts necessary to succeed once they are in engineering school. This raises interesting questions about the iconic role of mathematics and science in engineering education.

Clearly, there are differences between engineering and technology education as well as points of commonality (see Table 1).

Table 1
Points of Difference Between Engineering and Technology Education

Engineering	Technology Education
High barriers to entry	Low barriers to entry
Focus on theory and analysis	Focus on practical/hands-on
Large number of practitioners	Small number of practitioners
Training for research and practice	Training for teaching
Established discipline	Trying to become one
Established content	Evolving content
See technological literacy as being of minor importance to field	See technological literacy as main justification for the profession

Collaboration

Collaboration between engineering and technology education has taken many forms, reflecting the differing motives and cultures of the two groups. The collaboration I know best is that between ITEA and NAE, which began in the mid-1990s with discussions between Bill Wulf and Kendall Starkweather about the nascent ITEA standards. Rodger Bybee, then head of the National Academies science education unit, played a pivotal role in facilitating the dialogue, which moved very quickly to plans for engaging NAE as an informal reviewer of the standards. ITEA took a considerable risk in this venture, exposing itself not only to internal criticism but also to the scrutiny of highly accomplished engineers, most of whom knew nothing about technology education or, for that matter, educational standards.

Why was Bill Wulf willing to entertain the idea of a link to ITEA at all? For the National Academies, such direct work with outside organizations is very rare. Part of the reason was strategic. Wulf wanted to push the NAE to take a more active role in pre-college education issues, as his counterpart at the

National Academy of Science, Bruce Alberts, had done in science. ITEA and its standards presented an opportunity for NAE to connect directly with K-12 schools and to begin to carve out an educational niche—advocating for "technological literacy"—within the broader Academies organization. Wulf also harbored a very personal connection to technology education. He had taken numerous shop courses during high school.

The NAE-ITEA collaboration eventually expanded to include a much more formal review of the standards by the NRC. The review mimicked in almost every way the peer review process used by the Academies to vet its own reports prior to publication. The NRC review group, chaired by Wulf himself, proposed a number of substantive changes to the standards' content and organization, and the ITEA managers of the standards project, Bill Dugger and Pam Newberry, adopted nearly every one. A number of the changes refined and expanded the document's treatment of engineering concepts and the design process. The review process delayed publication of the standards by one year, to 2000. When the review was finally complete, the NAE Council proclaimed its strong support for the standards and urged their implementation (NAE, 2000).

Subsequently, with funding from the National Science Foundation (NSF) and the Battelle Memorial Institute, the NAE and the NRC's Center for Education (CFE) developed a vision for technological literacy in the United States, which was published in 2002 as *Technically Speaking: Why All Americans Need to Know More About Technology* (Pearson & Young). The 20-member committee that oversaw the project included two notables in technology education: Paul DeVore and Rod Custer. The book itself discusses technology education at some length, and a number of citations call out the important work and thinking of those in the field. Despite some critical reviews (Petrina, 2003), the book has generally been perceived as a helpful addition to the literature on technological literacy.

In 2003, NAE and CFE, with funding from NSF, began a follow-on project to *Technically Speaking* focused on the challenge of assessing technological literacy. Rod Custer and Bill Dugger represent technology education on the 16-member study committee for this project. The NAE recently received funding from the Department of Education to spread the word about technological literacy to state education leaders in mathematics, science, assessment, and curriculum. Technology educators will be involved in this effort as well.

Despite this encouraging history, much more needs to be done, even within the National Academies, to bring technology education into the mainstream of education policy discussions. The recently established Teacher Advisory Council, for example, which is supposed to bring a teacher's eye to the work of the Academies, comprises individuals with expertise in math, science, and instructional technology but not in technology education. An effort by the NAE in the late 1990s to involve technology educators in the work of the National Science Resources Center (NSRC), the curriculum-development arm of the

National Academies, fell flat, in part because the NSRC leadership held a negative view of industrial arts.

NSF, through its Bridges for Engineering program, has funded at least two projects—at Virginia Tech and the University of Georgia—that aim to encourage links between engineering and technology education. The Institute for Electrical and Electronics Engineering (IEEE) has launched an initiative to encourage dialogue between schools of education and schools of engineering (Institute for Electrical and Electronics Engineers, 2001, 2003), some of which house programs in technology teacher preparation. The IEEE conferences do not appear to have involved many technology educators.

Over the past year, a group of engineers has begun to explore the possibility of instituting advanced placement (AP) engineering in high schools. The effort is inspired in part by an accelerated technology education program within the Baltimore County Public School (BCPS) system. Students in the program take AP physics, higher-level mathematics, and engineering technology classes in grades 11 and 12. Those who do well in this track can receive college credit in engineering at the University of Maryland, Baltimore County. The program includes an engineering training and certification component for teachers. The NAE is trying to encourage organizers of the AP effort to take a broader view of engineering experiences in high school that is more consistent with technological literacy aims. The current vision seems mostly intended to satisfy the needs of the engineering pipeline.

The Baltimore initiative is unusual if not unique for its engineering-credit-granting feature. However, in the United Kingdom starting in the mid-1980s, engineering schools began to admit applicants who scored well on an exam based on the country's design and technology (D&T) curriculum. Engineering departments were persuaded to do this by the quality of design work done by many of the nation's D&T students (R. Kimbell, personal communication, Oct. 22, 2003). And in England, unlike the United States, a significant proportion of D&T teachers have engineering as their first degree. (Significantly, there are eight engineers teaching technology education courses in Baltimore County [M. Shealey, personal communication, Oct. 22, 2003]).

Massachusetts has received attention for the way it has tried to combine technology and engineering in K-12. In 2001, the state department of education adopted a new curriculum framework that includes specific reference to "engineering" alongside technology. Largely the result of the tenacious lobbying of former Tufts School of Engineering Dean Ioannis Miaoulis, the framework makes explicit the connection between engineering and technology in ways other standards documents fail. For the most part, the curriculum is being delivered by technology teachers.

Though there are certainly bright spots, formal collaboration between technology education and engineering appears limited in scope and to a certain degree lacking in vision. ITEA's linkage with NAE is significant and has potentially far-reaching implications for technology education. But outside that special case, which for the most part has not involved grassroots practitioners in either field, neither profession seems seriously interested in reaching out to the other.

Recommendations

Despite this somewhat pessimistic ending, I believe there are reasons to be hopeful. Uniting engineering and technology education in common purpose will not be easy, but it is possible. Like everything else in American education, it will require a sustained effort on multiple fronts. Here are some steps that might help get things moving in the right direction.

- Leaders and influential thinkers in both professions have to decide that the benefits of collaboration outweigh the risks. Technology education is in the more vulnerable position, with more to lose and gain, and so needs to be the more proactive partner, at least initially.
- Technological literacy, as expressed in the ITEA standards and *Technically Speaking*, should be exploited as a common theme around which engineering and technology education may build a meaningful relationship.
- The ITEA standards, as helpful as they are, do not provide any guidance for curriculum development. For the standards to be truly useful, technology educators need to think hard about how the content base in engineering—especially related to design—translates into content suitable for the K-12 classroom.
- Dialog that honestly explores each profession's strengths and weaknesses and respects each profession's history and culture will be needed to develop mutual trust and confidence.
- The role of mathematics and science in the curricula of both fields needs to be reexamined.
- Linkages between engineering and technology education in other countries, such as the United Kingdom, should be studied for lessons that might be applied in the United States.
- Engineering and technology education should work to build greater education research capacity within their ranks, with a goal of understanding better the nature of learning and effective teaching in their fields.

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Endnotes

[1]Actually, Mr. Dangerfield, whose given name is Jacob Cohen and who originally performed under the stage name Jack Roy, got his start in entertainment as a singing waiter.

[2]The contributions of engineering to quality of life and to safety are, of course, immense. The NAE's recently published book, "A Century of Innovation: The Engineering That Changed Our Lives (Joseph Henry Press, 2003), provides a well-documented and engaging review of the impact of engineering during the 20th century.