Fork in the Road: Choosing a Bright Future for Engineering

by **Dr. Stuart G. Walesh**, P.E., *Indiana Delta'63*

Samuel Florman's Fall 2007 BENT article, "Facing Facts About the Profession," compelled me to write this article. I must take issue with the somewhat pessimistic tone of Mr. Florman's views and respectfully offer a more positive perspective.

The purpose of this article is two-fold. First, by "facing the facts," to echo the title of the first article, my article demonstrates that significant segments of the U.S. engineering community are heading in a new direction regarding the formal education and early experience of engineers. Second, my article encourages current non-participants, whether individuals or organizations, to participate proactively and suggests how to do so.

Lest there be any misunderstanding, my purpose does not include presenting arguments for reforming the formal education and early experience of engineers in the U.S. Those arguments have, with increasing frequency during the last decade, been convincingly made by many. For example, see reports and other documents produced by various engineering organizations such as the American Academy of Environmental Engineers (AAEE),[1] American Society of Civil Engineers (ASCE),[2,3,4] National Academy of Engineering (NAE),[5,6,7] National Council of Examiners for Engineering and Surveying (NCEES),[8] National Society of Professional Engineers (NSPE),[9] and the University of Michigan.[10] Also note the writings of various visionaries cited in the next section of this article. Seeds planted by all of these individual and organizational calls for reform have borne fruit, reform has started, and it is growing.

VISIONARIES AND THEIR INFLUENCE

My writing of this article to somewhat counter Samuel Florman's article is ironic. For more than 30 years, beginning with his book, *The Existential Pleasure of Engineering*[11] and later *The Civilized Engineer*[12] and *The Introspective Engineer*[13] and his many articles, I have enjoyed, been enlightened by, and, most significantly, been inspired by his repeated, thoughtful calls for major improvements in our profession.

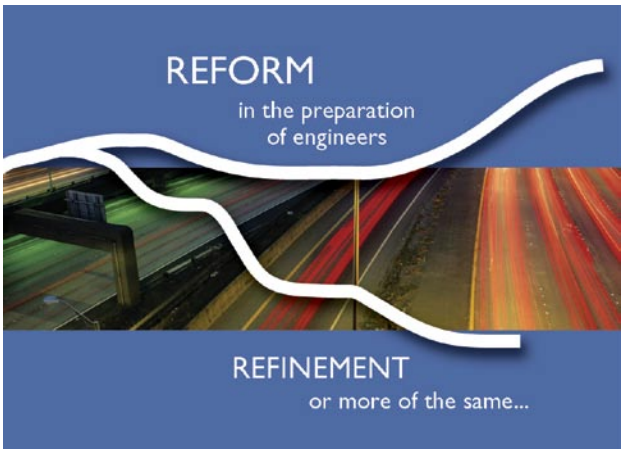
During that time, reform messages were offered by other visionaries including L.L. Guy;[14] R.K. Kersten;[15] L.G. Lewis Jr.;[16] D.H. Pletta,[17] *IL A '27;* J.M. Roesset,[18] *MA B '63;* and J.P.T. Yao.[18] Mr. Florman and others have, through their forward looking writing and speaking, urged engineers to extend and broaden their formal education, attract the "best and brightest" young people, enhance their value, seek leadership positions in government, expand mandated licensure, and influence public policy.

As a result of reading these many messages, I was motivated a decade ago to join others in proactively working for reform in the education and pre-licensure experience of engineers. Any contributions I may have made are due, in part, to Mr. Florman's and other thoughtful calls for reform.

I was taken back by the somber tone of Mr. Florman's most recent article and reread it several times. Although at one point he says "In the end, I come down on the side of optimism," he also offers many less than optimistic thoughts. Some examples:

- "I conclude that our profession has not evolved the way that I, and many of my colleagues, once assumed it would. The time has come to rethink some of our most cherished assumptions."
- "I conclude that American engineers will not play a significant role as legislators nor as officers in the executive branch of government, and perhaps that is all for the best."
- "…engineering remains a profession characterized by anonymity. Well, so be it."
- I wish it were otherwise, but I cannot sustain the belief that the four-year degree will be repudiated as the defining accreditation for the profession or that required licensing for engineers will become the norm."

I realize that the preceding quotes are not presented in their full context, and perhaps they were offered to jar more of us into action. Nevertheless, the statements reflect the tone of the article and convey a view of our profession's future that, in my opinion, represents a major compromise relative to Mr. Florman's and other earlier calls for raising the bar. Furthermore, his statements do not reflect recent developments that point to a bright future for our profession, or at least portions of it. His article, in effect, understates or does not adequately recognize the positive results of his and other's pioneering efforts—efforts that are now producing results. Therefore, I offer my different view in the hope of encouraging discussion.



THE FORK IN THE ROAD

According to former New York Yankee catcher Yogi Berra, "When you come to a fork in the road, take it." Robert Frost, using elegant prose, offered similar advice when he said "Two roads diverged in a yellow wood,… I took the one less traveled by, and that has made all the difference."[19] Some elements of our profession have come to that fork and have taken it by beginning to reform—not just planning to reform—the education and early experience of engineers. They have approached the divergence, taken the road less traveled or not yet traveled, and are seeing that the chosen path promises to make "all the difference."

Other elements of the engineering community are approaching the fork, that is, the diverging roads. They have the opportunity to take it; to travel on the road less traveled, the one that will make "all the difference." I hope that many do in the spirit of determining their future, rather than having others do it for them. While examining and striving to improve the full careers of engineers is desirable, clearly how we prepare and orient new members of the profession has highest priority. The reform effort begins at the beginning, as it should.

THE FACTS: REFORM ACTIONS

Table 1 summarizes definitive and strong reform actions taken by various U.S. engineering societies over the past decade. Some of these actions have, in turn, already caused changes, or will cause changes, in the education and early experience of engineers. As noted, the table includes strong definitive actions that already have or will lead to reform. Nothing listed in the table can be categorized as recommending *more of the same* or of just fine-tuning or *tweaking* the current approach. Presented below are thoughts to supplement information in Table 1.

ASCE: 1998 TO THE PRESENT

Reformation of U.S. engineering education has been studied and discussed for decades. B.E. Seeley,[23] to use his words, identifies "the main currents in various reform movements." He describes the gradual evolution of engineering education beginning with adoption of the Morrill Act after the Civil War that established land-grant schools that shifted the dominant pattern of "engineering education from shop floors to classrooms." He cites key studies including the 1927 Wickenden report that recommended less hands-on specialization and more attention to mathematics and science. The 1956 Grinter report stressed the value of engineering science and led to much more fundamental research. The controversial 1966 Walker report, according to Seeley, "proposed addressing overloaded curricula by instituting a generalized undergraduate degree and reserving specialization for the master's level."

While improvements have occurred in engineering education, they have been evolutionary, not revolutionary. These improvements fall short of reform. For example, at the end of his essay, Seeley offers this summary statement:

> *"Despite these changes, however, many of the challenges facing engineering educators have remained remarkably consistent over time. The question of what to include in tight curricula, how long engineering education should last, how much specialization there should be at the undergraduate level, how to prepare students for careers that include both technical and managerial tracks, and how to meet the needs and expectations of society all seem timeless."*

And, for about two centuries, engineering has, with few exceptions, adhered to four-year undergraduate education. This four-year degree has continued to be recognized as the engineering professional degree despite decades of scientific and technological advances, increased environmental concern, growing threats of disasters, and rapid globalization.

The ASCE board of direction's adoption and confirmation of Policy Statement 465[20] that "supports the attainment of the Body of Knowledge (BOK) for entry into the practice of civil engineering at the professional level" has already proven to be revolutionary, to have started reform. This is due, in part, to its uniqueness in that this is the first time a U.S.-based, discipline-specific engineering society has formally called for major reform of engineering education—including adding education beyond the bachelor's degree—and reform of pre-licensure experience.

Table 1 indicates that ASCE published two editions of *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future*.[21,22] The second edition uses Bloom's Taxonomy, which is widely known and understood within the educational community, to describe the minimum cognitive levels of achievement for each of the 24 outcomes. The outcomes, which are organized into three categories—foundational, technical, and professional—define knowledge, skills, and attitudes that are to be fulfilled by an individual prior to entering the practice of civil engineering at the professional level, that is, licensure. All 24 outcomes are fulfilled or partially fulfilled through the bachelor's degree. Three outcomes are partially fulfilled by a master's degree or equivalent, and 15 outcomes require experience as an engineer intern for complete fulfillment.

The preceding, relative to today's approach, and in keeping with Florman's and other calls for reform, mean that tomorrow's civil engineer will:

- Master more mathematics, natural sciences, and engineering science fundamentals;
- Maintain technical breadth;
- Acquire broader exposure to the humanities and social sciences;
- Gain additional professional practice breadth; and
- Achieve greater technical depth—specialization.

Notice how the outcomes provide specific answers,

Entity	Date	Action	Significance
ASCE board of direction	October 1998 (refined 10/01, 10/04, and 4/07)	Adopted a policy statement that, in its 2007 version, "supports the attainment of the Body of Knowledge (BOK) for entry into the practice of civil engineering at the professional level."[20]	First time that a U.S.-based, discipline-specific engineering society formally, and at the highest level, called for major reform of engineering education—including adding education beyond the B.S.—and pre-licensure experience.
NSPE	2002	Adopted a professional policy that "supports the concept of engineering students meeting additional academic requirements as a prerequisite for licensure and practice of engineering at the professional level. Additional requirements could include a master's degree or equivalent."[9]	First time that a pan-engineering society called for formal education beyond the bachelor's degree.
ASCE	January 2004 (Second edition published January 2008)	Published *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future.*[21,22] Defines, using Bloom's Taxonomy, the knowledge, skills, and attitudes required of an individual entering the practice of C.E. at the professional level (licensure) in the 21st Century.	The BOK has proven to be a productive forum for educators and practitioners. Examples of results to date include use of the BOK for program improvement at various universities, revision in accreditation criteria, and modification of the NCEES model law.
NAE	2004	Published *The Engineer of 2020* that concluded "…if the engineering profession is to take the initiative in defining its own future, it must (1) agree on an exciting vision for its future; (2) transform engineering education to help achieve the vision…."[5]	Ominously suggests that engineering is not now determining its future and points to transforming engineering education (not just fine-tuning) as an essential action. Leads to the upbeat, proactive 2005 NAE report below.
NAE	2005	Published *Educating the Engineer of 2020* stating, "The B.S. degree should be considered as a pre-engineering or 'engineer-in-training' degree. Engineering programs should be accredited at both the B.S. and M.S. levels so that the M.S. degree can be recognized as the engineering professional degree." [6]	First time that a U.S.-based, pan-engineering society called for dual-level accreditation and recommended the M.S. as the engineering professional degree.
NCEES	September 2006 (confirmed August 2007)	Approved modification to the licensure model law to require that an engineer intern with a bachelor's degree must have "… an additional 30 semester credits of acceptable upper-level undergraduate or graduate-level course work to be admitted to the P.E. examination."[8]	Effective in 2015, U.S. licensing jurisdictions that adopt this provision of the model law will require a master's degree or equivalent.
ABET	2007	Approved changes to the program criteria for civil and similarly named engineering programs and to general criteria for master's-level programs.[22]	These changes in criteria, to be applied first during the 2008-09 accreditation cycle, support the reform of C.E. education.

Table 1. Recent Milestones in Reforming the Education and Early Experience of Engineers

at least for civil engineering, to the questions asked by Seeley in his article.[23] More specifically, the BOK indicates the minimum content in terms of knowledge, skills, and attitudes to be included in curricula (and in experience) and addresses how long formal engineering education should last (bachelor's degree plus a master's degree or approximately 30 semester credits of acceptable graduate-level or upper-level undergraduate courses). The BOK also answers the specialization question (it should occur within the master's degree or equivalent) and how to prepare young people for careers that include both technical and managerial tracks (achieve greater technical depth while acquiring additional professional practice breadth). And finally, the BOK indicates that meeting the needs and expectations of society will be accomplished by the preceding plus broader exposure to the humanities and social sciences.

Because the BOK focuses on well-defined results—the outcomes—and does not prescribe the means to achieve them,[24] and because the BOK calls for "raising the bar," the BOK has already proven to be a productive forum for educators and practitioners and has produced concrete results within and outside the C.E. discipline. The BOK:

- Has been used to modify the ABET civil engineering program criteria and the ABET general criteria for master's-level programs and will continue to be used to improve at least the former.
- Is being used to design and/or revise engineering curricula at highly varied institutions. Some examples—just the tip of the iceberg—are the Univ. of Alabama,[25] The Citadel,[26] Univ. of Illinois,[27] Lawrence Inst. of Technology,[28] Rose-Hulman Inst. of Technology,[29] and the Univ. of Utah.[30]

- Has influenced the modification of the NCEES model law to require formal education beyond the bachelor's degree.[8]
- Has prompted elevated discussion of and work on the responsibility of practitioners to coach and mentor young engineers.[31] This is one result of the BOK indicating that experience is needed to complete fulfillment of about two thirds of the civil engineering outcomes.

While not necessarily related to the ASCE/BOK effort, other engineering disciplines have initiated BOK or similar projects. In November 2005, the American Academy of Environmental Engineers' board of trustees created the body of knowledge development working group and charged it with "defining the BOK needed to enter the practice of environmental engineering at the professional level (licensure) in the 21st Century...."[1] The chemical engineering profession driven in part by the recognition that, during the past 40 years, "the undergraduate curriculum in chemical engineering has remained nearly unchanged," conducted three workshops in 2003 that produced a vision and model for reform of undergraduate chemical engineering education.[32]

NAE: 2004 and 2005

The NAE 2020 project was motivated by the need to better prepare engineers to address issues such as globalization, the connection between education and practice, formulating solutions to increasingly complex problems, and appreciating the socio-political implications of their work.[5,6,33] The first of the two reports, *The Engineer of 2020*,[5] published in 2004, ominously suggests that engineering is not now determining its future and points to transforming engineering education as an essential action.

The second of the two reports, *Educating the Engineer of 2020*,[6] published in 2005, states "The B.S. degree should be considered as a pre-engineering or 'engineer-in-training' degree. Engineering programs should be accredited at both the B.S. and M.S. levels so that the M.S. degree can be recognized as the engineering professional degree." This NAE action is the first time that a U.S.-based, pan-engineering society called for dual-level accreditation and the M.S. as the engineering professional degree. The second report also issued this strong call for reform in the preparation of tomorrow's engineers:

> "It is evident that the exploding body of science and engineering knowledge cannot be accommodated within the context of the traditional four-year baccalaureate degree. Technical excellence is *the* essential attribute of engineering graduates, but those graduates should also possess team, communication, ethical reasoning, and societal and global contextual analysis skills as well as understand work strategies. Neglecting development in these arenas and learning disciplinary technical subjects to the exclusion of a selection of humanities, economics, political science, language, and/or interdisciplinary technical subjects is not in the best interest of producing engineers able to communicate with the public, able to engage in a global engineering marketplace, or [educated] to be life-long learners."

NCEES: 2006 AND 2007

As noted in Table 1, the NCEES approved modifications of the licensure model law to require an intern with a bachelor's degree to have "...an additional 30 [semester] credits of acceptable upper-level undergraduate or graduate-level course work from approved course providers" or a master's degree to be admitted to the P.E. examination.[8] U.S. licensing jurisdictions[34] that adopt this model law provision will, in effect, be requiring a master's degree or equivalent. A few licensing boards are already considering the model law's additional education requirement. For example, early this year, a bill was introduced into the Nebraska legislature that would require the 30 credits or a master's degree to be admitted to the P.E. examination.[35]

Dr. W. Gene Corley, P.E., *IL A'58*, NCEES president, notes that this new educational requirement will help protect the public. It is part of the progressive increase in standards envisioned 75 years ago by then NCEES president and future NSPE founder David B. Steinman, P.E., *NY A 1906*. Corley states: "Reviewing educational requirements remains an ongoing task in the 21st Century—one that NCEES has undertaken as part of its continuing efforts to assist U.S. licensing boards in protecting public health, safety, and welfare."[36] Given scientific and technological advances, increased concern with the natural environment, and threats of terrorism and natural disasters, how could we not at least occasionally raise the educational and licensure bars?

THE REST OF THE STORY

The preceding summarizes the definitive, strong reform actions of prominent U.S. engineering societies during the past decade. Clearly, engineering has come to a fork in the road, and segments of the profession are taking a new path. The facts indicate that engineering has experienced a tipping point.

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The first President of Tau Beta Pi's Indiana Delta Chapter, Dr. Walesh earned his B.S.C.E. at Valparaiso University, his M.S.E. at the Johns Hopkins University, and his Ph.D. at the University of Wisconsin-Madison. A member of ASCE and NSPE, he has served on and chaired committees and task forces and was editor of the 2008 ASCE report "Civil Engineering Body of Knowledge for the 21st Century." He has been recognized with awards from the Consulting Engineers of Indiana, University of Wisconsin, ASCE, and NSPE.

He authored or co-authored more than 200 publications and presentations in engineering, education, management, and leadership and has facilitated or presented hundreds of workshops, seminars, and webinars. Dr. Walesh is the author or co-author of five books including *Urban Surface Water Management* and *Managing & Leading: 52 Lessons Learned for Engineers*.

A more subtle but equally important tipping point is the emergence of a growing cadre of reformers. Major change and reform typically begin with the efforts of a core group that envisions a much better future, commits to making it happen, conceptualizes an implementation plan, and invites others to join the effort. The compelling vision and plan to achieve it attracts others. Already hundreds of engineers, drawn from various disciplines and from the public, private, and academic sectors have actively participated in the reform effort. Those members of various engineering societies have served on or chaired various committees, subcommittees, and task forces; spoken to hundreds of audiences; written papers, articles, and reports; and initiated improvements within their organizations. This cadre of committed individuals assures the continued success of the reform effort, at least within portions of the engineering community.

BUT, IF WE BUILD IT, WILL THEY COME?

Having observed over the years an array of responses to calls for reform of the engineering profession, I've noticed that even receptive academics and practitioners often respond with cautious, if not fearful, *but* statements. For example: "But if our engineering discipline raises the bar, won't students migrate to other engineering disciplines?" "But, if engineering raises the bar, won't young people select other professions?" (Note: With respect to the second question, they are, and most of those professions have already raised the bar higher than engineering.)

These questions raise some broader human-behavior questions that warrant attention. What happens when expectations are raised in our personal, professional, and community lives? What happens personally and organizationally when expectations remain fixed or decline, when the bar stays in place or is lowered? What kind of people are attracted to a raised bar, and what kind are repelled by it?

As a middle-school student, I remember learning about the insurmountable four-minute mile—no one could do it. Then, on May 6, 1954, Englishman Roger Bannister ran a 3:59.4 mile. The raised bar immediately attracted the best runners. Within a month, Australian John Landy beat Bannister's time, and, later that summer, in a widely publicized race, Bannister, with a time of 3:58.9, beat Landy.[37] A half-century later, the four-minute mile is the standard for male runners. Many, including high-school athletes, have run sub-four-minute miles with some having accomplished this feat 100 times.[38] In summary, the mile bar was raised, the best runners responded, and new records were set.

At one point in my career, I served as dean of a small engineering college. My duties included meeting with prospective engineering students and their parents. One particular young lady, probably a high-school senior, was doing her homework about professions—engineering, medicine, law, and business. She asked me how many years were required to earn an engineering degree. I proudly told her that, at least in our program, the average completion time was essentially four academic years. Her reply, which was something like, "if it only takes four years, it can't be worth much," surprised me and later caused me to reflect. Her view suggested to me then, as it does now, that young people—especially bright, ambitious young people—may view longer, more rigorous academic programs as an asset, not a liability.

What happens in our personal life when the bar is raised? Do we respond by going elsewhere, or are we attracted to the challenge and rise to the occasion. This depends in part, on who "we" is. Recall those multiple-section college courses when you had a choice of professors. Typically one professor was known as being well prepared, having high expectations for his or her students, and being supportive. The other professors were, as we used to say then, "easy." What kind of students selected the section taught by the "hard professor"? Most of you know because you were in that section. You and some of your fellow students were bright, ambitious, diligent, and appreciative of the special learning opportunity offered by the "hard prof." Similar self-selection occurred when the institution offered extra opportunities such as independent studies, honors courses, undergraduate research, and international study.

While individual anecdotes like the preceding prove nothing, cumulative experience teaches that a raised bar becomes a magnet for the "best and brightest." Reforming engineering or portions of engineering, by elevating the education and early experience expectations will, in my view, attract even higher caliber young people to the entire profession, or at least to those reformed, more demanding portions of the profession. Numbers of students may drop, either temporarily or permanently, but the goal is quality, not quantity.[39] Some engineering programs may go by the wayside. Again, our focus should be in improvement, reform, and the quality of offerings. U.S. engineers must offer added value to compete in an increasingly globalized society. Playing a numbers game is a sure way to lose the global competition.

During the last century, other professions reformed the content and length of their educational and other requirements. Examples are accounting, architecture, audiology, dentistry, law, medicine, nursing, optometry, pharmacy, and veterinary medicine.[3] Consider, as an example, the raise-the-bar experience of the accounting profession which began implementation in the 1980s of a requirement to complete 150 semester credit hours as a condition for sitting for the C.P.A. examination. Guam, DC, Puerto Rico, and 44 states have adopted this criterion.[40] National accounting enrollments have been increasing since 2000, but difficulty in finding faculty is a constraint.[41] For example, during 2001-05, total enrollments in accounting bachelor's programs in three Maryland universities increased 15 to 20 percent per

year.[40] While views continue to vary among both accounting educators and employers nationally, the predominant thinking is that the additional education has the potential to strengthen the profession, especially when delivered in re-designed and integrated curricula or separate master's degree programs.[41]

And, what has engineering done? Our four-year engineering education model, paralleling the four-year liberal arts model, dates back 200 years to the 1802 founding of the first U.S. engineering program at West Point. Other professions, some of which started their formal education after engineering and in a more modest manner, have passed us by in duration, breadth, and depth of formal education required for professional practice.

Perhaps engineering can take some comfort in not having lowered the bar. Assume, in spite of the reduced number of credits required for the bachelor's degree, shortened semesters, and grade inflation, that the engineering bar has not been lowered. However, when other professions raise their bars, our profession's bar is, in a relative sense lowered. And, let's not think that the most qualified young people don't notice.

However, the future is bright. As indicated earlier in this article, engineering reform has begun. Disciplines that pioneer the reform effort may experience a decline in the number of students they attract—a loss of those young people who seek an easier route. More importantly, the pioneering disciplines will attract a larger absolute number of bright, ambitious, diligent, and appreciative students who want educational programs that prepare them for challenging and satisfying careers in the 21st Century.

And those students will increasingly include women who are still grossly under represented in our engineering schools.[42] Low participation by women in engineering, relative to society and to professions such as business, law, and medicine, is one of our profession's most serious and embarrassing problems. Perhaps a significant number of young women, like the high-school student I mentioned, view engineering as too easy, as not worthy of their attention given the profession's limited educational expectations. A profession cannot prosper when it "effectively cuts itself off from half of its potential talent pool."[43] "Balancing the equation is not just about girls and women, it is about harnessing the intellectual capital in future leadership in science, engineering, and technology."[44] The good news is that as a result of raising the bar, portions of engineering will begin to draw more evenly on both halves of the talent pool, not just primarily the male half, and as a result significantly strengthen their disciplines.

YOUR POSSIBLE ROLE

Assume, in keeping with the first purpose of this article, you agree that significant segments of U.S. engineering are heading in a new direction and you want to contribute or contribute more to the effort. Maybe experience has taught you the essence of philosopher Arthur Schopenhauer's thought that "all truth goes through three stages. First it is ridiculed, then it is violently opposed, finally it is accepted as self-evident." The need for and the beginnings of reform are, in my view and perhaps yours, self-evident.

How could you become an active or more active participant and contributor? The short answer is "many ways" and don't wait to be invited. Recognize that the reform movement described in this article has been and will continue to be essentially volunteer driven and volunteer staffed. As succinctly stated by Richard G. Weingardt, P.E., *CO E '60*, "the world is run by those who show up."[45] The longer answer to the "what could you do" question follows in the form of possible concrete "show up" actions.

- Come up to speed, if much of this is new to you, by reviewing some key documents cited in this article. They are available at no cost via the web. Perhaps your colleagues, whether in an engineering company, public agency, or university, could devote some quality time to discussing key documents.
- Communicate with your technical society's educational committee or board (e.g., the IEEE educational activities board) and determine its position on, and efforts toward, reform. Having served on such volunteer groups, I know that some have a heavy load of routine work and may not be devoting resources to new initiatives. Find out. Offer to help.
- Invite a reform leader to speak at a meeting of your professional society. You will find their names and contact information in the previously mentioned key documents or through your professional society. They typically welcome opportunities to present status reports and obtain input for what is typically an evolving reform process.
- Contact faculty at your *alma mater* or a university where you, as a private or public-sector practitioner, recruit engineers. Ask them how they view the reform effort, and offer to assist.
- Express your views in a letter to the editor or an opinion column in your professional society's publications. Or, better yet, write an article. As noted by publisher Malcolm Forbes, "Putting pen to paper lights more fires than matches ever will."
- Present a paper at an appropriate conference, such as the annual ASEE conference or that of your specialty engineering society. Preparing for and delivering a presentation and then interacting with the audience enables you to articulate and test your views.
- Determine your licensing board's position on the model law, and urge discussion of its implications for the future of professional engineering.
- If you are on an engineering faculty, brief your department, other departments, and/or advisory boards on recent reform developments (e.g., give them this article), and request their views and support in implementing major changes within your college.

A ROLE FOR TAU BETA PI?

The rapidly growing number of engineers, who during the past decade have worked on reform of the education and early experience of engineers, includes many Tau Bates. Their election to Tau Beta Pi

marked them as scholars whose professional interests would later cause them to improve the engineering profession. Thus, indirectly, Tau Beta Pi has joined with AAEE, ASCE, NAE, NCEES, NSPE, and other engineering societies in leading reform.

Tau Beta Pi's indirect role in reform raises the issue of its potential direct role, a possibility illustrated by pondering some questions. Does Tau Beta Pi, as "the only honor society representing the entire engineering profession," have a responsibility to participate in reform of the means by which young people enter that profession? Is the publication of articles in THE BENT a form of participation? Should a society whose creed is "Integrity and Excellence in Engineering" stand on the sidelines as other societies actively define elevated excellence in engineering education for the 21st Century? Can Tau Beta Pi, with broad ranging programs such as Distinguished Alumnus, K-12 Math and Science Initiative, and McDonald Mentor, not be involved in the reform effort that addresses its core interest, engineering education? Can a society that "marks in a fitting manner" those who have demonstrated "distinguished scholarship" not participate in influencing the curricular and extra-curricular programs within which "exemplary character" will be demonstrated? Can the Society whose mission includes fostering "a spirit of liberal culture in engineering colleges" not be part of a reform effort that is doing just that?[46] Does Tau Beta Pi want to be noticed by its absence from the reform effort?

I cannot begin to answer these questions. However, they seem relevant and Tau Beta Pi has not recently addressed these issues in light of the reform effort that is underway. Given the Society's history; commitment to character, scholarship, and fostering a spirit of liberal culture; and its pan-engineering responsibility and influence, perhaps the Association should explore its potential role in this growing reform movement that has passed the tipping point.

CONCLUDING THOUGHTS

Our profession has only two futures, the one we create for ourselves or, in a *vacuum* of inaction and reaction, the one others create for us. As a profession, or as components of a profession, we can either continue to be largely reactive, or we can transform ourselves by becoming proactive.

Some readers may be uncomfortable with my stated one-or-the-other proposition. You dislike extremes—you prefer a middle ground. In my view, a middle ground won't suffice given what is at stake, namely attracting the highest quality young people to engineering, meeting society's increasingly complex environmental and infrastructure needs, and dealing with rapid change around the globe. As a profession, our collective mindset must be one of being in charge of our destiny, of being the windshield and not the bug.

Consistent with the first of the two stated purposes of this article, I have shown that some elements of the U.S. engineering profession are proactively creating their futures by reforming the education and early experience of engineers and taking other actions. They are succeeding; they are seeing benefits. However, engineering and, more importantly, society would be better served if the entire profession embarked on reform in keeping with the earlier, pan-engineering, visionary calls of Samuel Florman and others.

Consistent with the second purpose of this article, possible roles for you are suggested. If you are not already involved, please join the reform effort and encourage others to do the same. If little is happening, start the reform of your department, college, professional society, or other organization. Even if you oppose the reform that is underway, get involved. You may initially feel powerless or even intimidated because you are only one person in your department, or you and your colleagues are only a handful in your college, or your reform-minded group is miniscule in number relative to the size of your technical society.

Vision, commitment, and teamwork are the necessary ingredients for reform, not large numbers. As wisely stated by anthropologist Margaret Meade and as has been demonstrated by the reform that is now underway, "Never doubt that a small group of committed people can change the world. It is the only thing that ever has."

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14. E.g., see Guy, L.L. 1986. "I Accuse U.S. Practicing Engineers, Myself Included, of Shameful Neglect of Engineering Education," *Engineering Times*, September, p. 5.

15. E.g., see Kersten, R. H. 1996. "Engineering Education: Paragon or Paradox," *Journal of Professional Issues in Engineering Education and Practice–ASCE*, Vol. 122, No. 4, pp. 147-150.
16. E.g., see Lewis Jr. L.G. 1999. "A Model for Engineering Practice in the Twenty-First Century," THE BENT of Tau Beta Pi, Summer, pp. 12-15.
17. E.g., see Pletta, D.H. 1974. "The Making of a 'Pro'—A Faculty Viewpoint," *Engineering Issues–Journal of Professional Activities–ASCE*, July, pp. 217-223 and Pletta, D.H. and J.B. Eades. 1997. "What If," *Journal of Professional Issues in Engineering Education and Practice–ASCE*, January, pp. 35-37.
18. E.g., see Yao, J.T.P. and J.M. Roesset. 1999. "Civil Engineering Curricula for the First Professional Degree," *Forming Civil Engineering's Future*, J. Rogers and B. Brenner, Editors, ASCE, Reston, VA, pp. 89-94.
19. Robert Frost's "The Road Not Taken" is interpreted here as taking the road less traveled resulted in a positive "difference," a favorable result. Other readers challenged this interpretation and interpreted Frost as saying that the two roads were similar. However, the traveler, having chosen one, committed to having it become the best choice. See, for example, Schwehn, M.R. and D.C. Bass. 2006. *Leading Lives That Matter*, Chapter 7, "How Shall I Tell the Story of My Life?," William B. Eerdmans Publishing Company, Grand Rapids, MI.
20. ASCE, Policy Statement 465 as adopted by its board of direction, April 24, 2007. (*www.asce.org/raisethebar*)
21. ASCE Body of Knowledge Committee. 2004. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future*, Reston, VA, January. (*www.asce.org/raisethebar*)
22. ASCE Body of Knowledge Committee. 2008. *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future – Second Edition*, Reston, VA, January. (*www.asce.org/raisethebar*)
23. Seeley, B.E. 2005. "Patterns in the History of Engineering Education Reform: A Brief Essay," in Appendix A of *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*, National Academy of Engineering, Washington, DC, 2005, pp. 114-130.
24. While the BOK clearly prescribes levels of achievement for each of the outcomes, the detailed means to achieve those levels are not prescribed. The outcomes are presented without consideration of courses, faculty expectations, co- and extra-curricular activities, access and delivery systems, employer's training programs, and other administrative and logistical aspects of teaching and learning during education and early experience.
25. Fridley, K.J., 2007. "Policy Statement 465," Editorial, *STRUCTURE Magazine*, March, p. 7. The external advisory board of the University of Alabama, department of civil, construction, and environmental engineering, unanimously embraced the ASCE Policy Statement 465 and the BOK, the undergraduate curriculum was restructured to incorporate the BOK, and pre-college recruitment includes advice to pursue an M.S. degree. Results four years into the effort: Doubled undergraduate enrollment and increased student quality based on high-school GPA and ACT/SAT scores.
26. Brannan, K.P., head, department of civil and environmental engineering, The Citadel, January 21, 2008, personal communication. The ASCE BOK forms the core of the department's ABET assessment process. The BOK outcomes were adopted in 2005 to reflect the skills and attributes all civil engineering students were expected to fulfill by graduation. Outcomes map the educational objectives of design, sustainable success, and broad-based education.
27. Lange, D.A., associate head, department of civil and environmental engineering, University of Illinois at Urbana-Champaign, January 24, 2008, personal communication. The department's curriculum committee is revising its undergraduate and master's curricula in anticipation of greater demand for the M.S program. Changes include better integration of professional issues in undergraduate courses, earlier exposure to laboratories and learning by doing, greater accommodation of study abroad and undergraduate research, a more streamlined M.S. curriculum, and improved academic advising.
28. Carpenter, D., department assessment coordinator, department of civil engineering, Lawrence Technological Institute, January 29, 2008, personal communication. The BOK as presented in ASCE's *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future–Second Edition* is being used as the basis for curricular improvements in anticipation of the 2010 ABET visit.
29. Sutterer, K.G., department of civil engineering, Rose-Hulman Institute of Technology, January 27, 2008. The department found that its undergraduate program was almost aligned with the BOK, used the BOK as assessment tool in preparing its last ABET report, and is planning for an M.S. degree.
30. Elliot, T., department ABET facilitator and member of College ABET committee, department of civil and environmental engineering, University of Utah, December 24 and 27, 2007, personal communication. Results of the first edition of the BOK have been used to eliminate ambiguity in levels of achievement criteria; to obtain quasi faculty communication positions; to respond to industrial advisory board concerns; and to enable the department to assume a leadership role in the college. The college ABET committee approved the BOK as the baseline planning document for preparing for the next ABET evaluation.
31. ASCE formed the BOK experiential fulfillment committee in 2008 and charged it to prepare guidelines to assist engineer interns to fulfill BOK outcomes through on-the-job experience, education, and training.
32. Armstrong, R.C. 2006. "A Vision of the Chemical Engineering Curriculum of the Future," *Chemical Engineering Education*, Vol. 40, No. 2, pp. 104-109.
33. Smerdon, E.T., and J.S. Russell. 2007. "*Two Comprehensive U.S. Studies of Engineering Education Reform*," International Conference on Engineering Education, Coimbra, Portugal, September.
34. Engineers are licensed in 50 states, DC, and four U.S. territories (Guam, Puerto Rico, Northern Mariana Islands, and the Virgin Islands) for a total of 55 jurisdictions. Illinois has a separate board for structural engineering. Thus, there are 56 boards that license engineers. For an historical account of U.S. engineering licensure, see McGuirt, D. 2007, "The Professional Engineering Century," *PE*, June, pp. 24-29 and for thoughts on the future of licensure, see Nelson, J.D. and B.E. Price, 2007, "The Future of Professional Engineering Licensure, *PE*, June, pp. 30-34.
35. Legislature of Nebraska. 2008. "Legislative Bill 742," January 9.
36. Corley, W. G. 2007. "New Educational Requirement Will Help Protect Public," *PE*, December, p. 8.
37. Academy of Achievement, *www.achievement.org/autodoc/page/ban0bio-1*, January 7, 2008.
38. Wikipedia, *en.wikipedia.org/wiki/Four-minute mile*.
39. Since ASCE adopted Policy Statement 465 in October 1998, undergraduate C.E. enrollment rose 31%, from 36,281 to 47,524 in 2006, a record high. Cause is unknown. Source: Engineering Workforce Commission. 2007. *Engineering and Technology Enrollment–Fall 2006*, American Association of Engineering Societies.
40. Logan, R. 2007. "Rigor and Reward," *Baltimore Business Journal*, December 7-13.
41. Reigel, D., director of academic and career development, AICPA, February 7, 2008, personal communication.
42. Only 19% of the 2006 engineering bachelor's degree recipients were women, the lowest representation in the last decade, even though women comprise 57% of the undergraduate population. See Loftus, M. 2007. "Why Won't She Listen?," *PRISM*, ASEE, December, pp. 26-31.
43. Baker, B. 2001. "Patti and Glass Ceiling," *PM NETWORK*, May, p. 23.
44. Thom, M. 2001. *Balancing the Equation: Where are Women in Science and Engineering Technology?* National Council for Research on Women. The quote is in a brochure that describes the report.
45. Weingardt, R. G. 1997. "Leadership: The World is Run By Those Who Show Up," *Journal of Management in Engineering –ASCE*, July, pp. 61-66.
46. Tau Beta Pi, *www.tbp.org*, January 14, 2007. For detailed information, refer to "About Tau Beta Pi" noting, in particular, the Society's mission and vision, history, and programs.