AC 2008-2662: BEATING THE COMPETITION DOWN WITH THE STICK OF EDUCATION: A WINNING STRATEGY FOR A GLOBAL WORLD

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Beating the Competition down with the Stick of Education: 
A Winning Strategy for a Global World

Introduction:

In his book, *Is America Falling off the Flat Earth*¹, Norman Augustine highlights the sharp competition that the U.S. has begun to face in the world stage:

…our competitors have not been standing still. The World Economic Forum dropped America from first to seventh place in its ranking of nations’ preparedness to benefit from advances in information technology; the number of US citizens entering engineering school declined still further; the remnants of the legendary Bell Labs, the birthplace of the laser and the transistor and the home of many Nobel laureates, were sold to a French firm; a new generation of semiconductor integrated circuits—the mortar of the modern electronics revolution—was introduced; the largest initial public offering in history was conducted by a Chinese bank; another $650 billion has been spent on US public schools while the performance of its students on standardized science tests of those about to graduate declined further; American companies once again spent three times more on litigation than on research; and in July, for the first time in history, foreign automakers sold more cars in the United States than American manufacturers.

Even taking account of Nobel prize-winning economist Joseph Stiglitz’s caveat that the world is far from becoming flat for many in developing countries², most could probably find themselves agreeing with the alarming tone of the quoted material in the preceding paragraph. This paper will make suggestions as to how we might construct educational strategies that would help America prevail over this competition³⁻⁶.

The default strategy that has evolved without much foresight in high tech areas, has been the cultivation of major global partners like India and China. As engineers and educators, we have to ask how this impacts what we teach in the classroom. Having listened to numerous presentations on industry needs, we believe that industry would embrace a new breed of engineers and technologists to manage US technological and financial interests around the world. This is a rational approach based on ground realities. India and China together out produce the U.S. 30 to 1 in engineering graduates, and their graduates get paid one eighth of what a U.S. graduate will need⁷. If we want to maintain our technological and economic might, we certainly must make good use of the talent that exists around the world. Industry seems to be taking a two pronged approach to engineers and technologists. They are emphasizing the need for soft skills for engineers and technologists. They are emphasizing the need for soft skills for engineers and technologists, and a more systems approach for the technician (as an example they would like an electronic technician education where components are de-emphasized in favor of a systems approach⁸).

No one can disagree with the importance of soft skills to engineers and technologists in a global economy; however, the approach to technician training needs to be studied more carefully³⁻⁵, 8, 9. A truly successful global technological strategy will require us to move from having two major partners, to many major partners in technology². Indeed, the more successful we become, the greater will be the need for U.S. engineers and technologists. We submit that to meet this anticipated need for engineers and technologists can be
managed by helping technicians to obtain higher degrees. Our paper will discuss how we can satisfy the need for industry while keeping the door open to vertical integration for technicians.

So how can US universities provide an adequate number of well trained engineers and technologists that will successfully steer our economy through the turbulent age of globalization? While the answer to this question depends to some extent on the dynamics of the social, the political and the economic situations, we feel that it is still safe to make the following assumptions,

1. The external (worldwide) and internal (US) forces of globalization are such that the US economy will need to continue to participate and compete in a world economy that promotes multinational partnerships.
2. The “wage disadvantage” felt by US companies hiring US engineers and technologists will remain. However, regulatory requirements, national security concerns, and a higher caliber of training received at US schools are some of the factors that can be used to justify higher wages for US workers.
3. The demand for US engineers and technologists, will continue grow despite the “wage disadvantage”. One of the leading causes for this increased demand will be the need to have engineers and technologists manage US technological and financial interests around the world.
4. As a consequence of item ‘3’, the numbers of engineers and technologists will need to increase.
5. Also, as a consequence of ‘3’, additional new skill sets will be needed in training engineers and technologists for the future. The National Engineering Academy (NAE) task force for Engineer 2020, the Accreditation Board of Engineering and Technology (ABET) for both the Engineering Accreditation Commission (EAC) and Technology Accreditation Commission (TAC) are all either proposing or requiring that engineering and technology students demonstrate some global skills.

Based on our assumptions, the pursuit and subsequent training of technical talent need to be a high priority. We need to identify the skill sets (technical and otherwise) that are appropriate for workers of a leading nation competing in a global marketplace. The following sections will explain how we think a high quality workforce can be trained and deployed in sufficient numbers to meet the expected rise in demand.

**Identifying Global Skill Sets:**

We begin by discussing quality related issues. It is essential to select a well thought out student learning outcome set before proceeding to teach and assess global skills. In this section, we will present two such student learning outcome sets that embody desirable global skills needed by engineers and technologists.

A comparative look at different criteria and student learning outcomes for global skills can be seen in table 1. The first two columns in table 1 are ABET criteria for the
Engineering Accreditation Commission (EAC) and Technology Accreditation Commission (TAC) that explicitly address global skills. Both the EAC and the TAC statements are very broad and include societal, professional and global issues. Individual programs may find it difficult to create their own list of global student learning outcomes based on the ABET criteria alone, and as such, adopting either of the SLOs listed in columns three or four may provide an adequate baseline.

Columns three and four of table 1 contain focused lists\textsuperscript{15,16} of student learning outcomes that address global competencies. Professors Lucena and Downey\textsuperscript{15} design to achieve what they regard as the bedrock essence of global competency:

\begin{quote}
\textit{Through course instruction and interactions, students will acquire the knowledge, ability, and predisposition to work effectively with people who define problems differently than they do.}
\end{quote}

Indeed, Lucena and Downey, suggest that EAC of ABET consider adding the above statement as criterion 3 L in their program outcomes\textsuperscript{12}.

The Global Engineering Education (GEE) outcomes of column four\textsuperscript{16} is similar to the list provided in column three. The GEE outcomes are a product of the first GEE Symposium at Arizona State University, held in February, 2004. GEE has defined global competency as blending of technical and social skills:

\begin{quote}
\textit{the ability to see and enable the coordinated progression of Technological and Cultural/Social capabilities throughout the world.}
\end{quote}

There is a great deal of overlap between the two sets of outcomes (Table 1 GREEN ZONE). The GEE list can actually be considered to be a superset of the Lucena and Downney list. We believe that both lists can be used as effective student learning outcomes to teach and assess global skills to engineers and technologists. An example of the application of the GEE list in assessing global skills can be found in a paper by Khan\textsuperscript{17}.

**Teaching Global Skills (The Search for a Low Cost Approach):**

There is great deal of literature\textsuperscript{4,9,17-23} regarding the teaching of global skills. Some researchers have used industry funding\textsuperscript{19,21} to study the problem, while others are currently searching for sources of funding\textsuperscript{22}. While seeking funds to enhance global educational experiences for students is a worthwhile pursuit, it is no longer possible to delay teaching these skills. Given the urgency at hand, we believe that great strides can be made by leveraging available resources in every campus. Following is a list of some low cost options that can be effective in teaching global skills.
<table>
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<tr>
<th><strong>ABET’s Engineering Accreditation Commission (EAC)</strong></th>
<th><strong>ABET’s Technology Accreditation Commission (TAC)</strong></th>
<th><strong>Student Learning Outcomes based on the criterion of global competency (CGC)</strong></th>
<th><strong>Global Engineering Education (GEE) outcomes for students</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context</td>
<td>(j). a respect for diversity and a knowledge of contemporary professional, societal and global issues</td>
<td>(a) “Students will demonstrate substantial knowledge [or factual understanding] of the similarities and differences among engineers and non-engineers from different countries.”</td>
<td>The ability to place knowledge within a social context</td>
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<td></td>
<td>(b) “Students will demonstrate an ability to analyze how people’s lives and experiences in other countries may shape or affect what they consider to be at stake in engineering work.”</td>
<td>– Demonstrate globalized technical knowledge</td>
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<td>(c) “Students will display a predisposition to treat co-workers from other countries as people who have both knowledge and value, may be likely to hold different perspectives than they do, and may be likely to bring these different perspectives to bear in processes of problem definition and problem solution.”</td>
<td>– Awareness of relevant factors in a global</td>
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<td>(d) “Students will display a predisposition to treat co-workers from other countries as people who have both knowledge and value, may be likely to hold different perspectives than they do, and may be likely to bring these different perspectives to bear in processes of problem definition and problem solution.”</td>
<td>– Synthesis of engineering and culture and communication technology systems</td>
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<td>(e) “Students will display a predisposition to treat co-workers from other countries as people who have both knowledge and value, may be likely to hold different perspectives than they do, and may be likely to bring these different perspectives to bear in processes of problem definition and problem solution.”</td>
<td>– Cross-cultural fluency</td>
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<td>(f) “Students will demonstrate an ability to analyze how people’s lives and experiences in other countries may shape or affect what they consider to be at stake in engineering work.”</td>
<td>– Adaptable to new environment</td>
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<td>(g) “Students will display a predisposition to treat co-workers from other countries as people who have both knowledge and value, may be likely to hold different perspectives than they do, and may be likely to bring these different perspectives to bear in processes of problem definition and problem solution.”</td>
<td>– Increased disposition to work in a global economy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context</td>
<td>– Competition in the job market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(i) “Students will display a predisposition to treat co-workers from other countries as people who have both knowledge and value, may be likely to hold different perspectives than they do, and may be likely to bring these different perspectives to bear in processes of problem definition and problem solution.”</td>
<td>– Improved communication skills</td>
</tr>
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</table>

Foreign Students Panels: Foreign students bring with them a wealth of cultural and economic information that can be channeled into enriching experiences for U.S. students. A Lucena outcome\(^{15}\), for instance emphasizes the importance of students grasping regional and cultural differences: “Students will demonstrate substantial knowledge [or factual understanding] of the similarities and differences among engineers and non-engineers from different countries.” A panel of graduate students from country X (a mix of engineers and non-engineers) can provide valuable perspectives in a properly
facilitated discussion. U.S. students attending this program would also have the opportunity to ask questions to further enhance their understanding.

Facilitated Discussions: In a case study taken from a paper, students are asked to compare two distinct types of the innovative processes: the development of the Apple’s iPod, and Intel’s plan to provide inexpensive computers to rural India. Obviously, Apple’s iPod targeted an entirely different market from the one Intel was seeking to attract. Both cases were discussed in light of people, place, product, price, promotion and process (popularly known as the 6Ps of innovation). Following this, a survey was administered to technology students in a freshman seminar course. The survey results were analyzed using GEE outcomes. This exercise is an example of what may be accomplished using facilitated discussions. Facilitated discussions could also be used in concert with a panel discussions (like foreign student panels for example) to improve comprehension and understanding of global skills. This, of course, requires a skilled facilitator who can bridge the discussions between cultures.

Foreign-born Faculty: U.S. schools of engineering and technology are well populated with faculty members who are foreign born. Some of these professors have good connections with the academic institutions and businesses in their home countries. This resource should be tapped. Foreign-born faculty members have created networks and bridges to other parts of world in collaborative educational ventures. These same professors can provide valuable cultural insights to students even within the boundaries of the classroom. Foreign-born faculty members also tend to be from those parts of the world that most keenly compete with us, making their help in teaching global skills that much more useful.

International Experience: Like student internships before them, international experiences are becoming increasingly vital to the overall training of engineers and technologists. While this is an added cost to students and their families, there is really no better way to accomplish Lucena’s third outcome or corresponding GEE outcomes than to spend time abroad. Embedding students in a foreign culture is the type of sink or swim situation that can prepare students to develop the cross cultural skills needed to thrive in such climates.

Increasing the number of Engineers and Technologists:

There are approximately 70,000 engineers who graduate annually from different engineering schools in the U.S. Unfortunately, the exact number of technologists that graduate each year with baccalaureate degrees (B.S. degree holders in Engineering Technology) is unknown, partly because the U.S. Department of Labor does not have a formal classification for technologists. Nonetheless, assuming that there are approximately 130-140 four-year technology programs, we believe the number should be well below 10,000. A difficulty associated with increasing the number of engineering graduates is that the number of students inclined to study engineering, despite having the
necessary aptitude, is relatively limited. While the demand for engineers is on the rise, the number of new college graduates has not changed appreciably.

We believe that engineering programs need to market themselves to non-engineering types who are capable of thriving in an engineering program, but choose to study business, given their interest in management and leadership. Engineer 2020 clearly indicates the importance of leadership and management to engineers. The aforementioned attributes, along with cultural skills, are key factors in improving our global competitiveness. Advertising these new requirements will perhaps broaden the appeal of engineering programs to students well prepared in math and science who are primarily interested in careers in management and leadership.

We also need to supplement some of the work that was traditionally done by engineers with work done by technologists. The National Society of Professional Engineers (NSPE) differentiates between the engineer, on the one hand, and the engineering technologist on the other, by emphasizing how engineering graduates design projects, while engineering technology graduates implement them:

*Engineering technology is defined as “that part of the technological field that requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational spectrum between the craftsman and the engineer at the end of the spectrum closest to the engineer.” In other words, the engineer is the person who conceives the design, while the engineering technologist is the person who implements it.*

National salary trends, positions held by engineering technology graduates, and employer feedback, however, would suggest that the NSPE definition is oversimplified. Senior design projects, and in some cases six-sigma\(^{24}\) training, do provide engineering technology students with good design experience. While engineering technology students have fewer mathematical tools at their disposal, we feel that they are still capable of being valued as designers in many areas. In other words, properly trained technologists are capable of both design and implementation.

We have come to a point where the number of engineers that the U.S. can produce annually is shrinking because of a shortage of students having the interest and capability to study engineering. We believe that engineering technologists could help to close that gap. Such graduates have the skills to take up positions oriented toward design and innovation,, and the profession could be made more attractive to them if programs stressed the ways that such skills integrate with managerial roles.

If we are to take advantage of the potential of technologists to enhance our global competitiveness, we must devise new pathways to encourage A.A.S. degree holders and certificate holders to seek engineering technology degrees (thereby increasing the number of technologists). Traditionally, community colleges have done a good job of preparing technicians for industry, but graduates of two-year technical programs have more difficulty in getting appropriate credit for their technical courses. When transferring to a four-year program, a direct equivalency is not always possible due to regulatory
requirements, but, in an outcome-based culture, it should be possible to create supplementary 1-credit or 0-credit courses that make such transfers possible.

Summary:

At the outset of this paper, we studied the global competition that makes it necessary to increase the number of well trained engineers and technologists. We then listed the kinds of global learning outcomes that are needed to enhance the education of this workforce, and enumerated ways to teach these skills to students without incurring excessive costs. In addition, we discussed different strategies to increase the overall numbers of globally competent engineers and technologists. It is our belief that more students will choose to study engineering when they are told that engineers with management and leadership skills are highly desirable. For example, students, who would otherwise become business majors due to an inherent need to manage and lead, can now visualize engineering or technology as alternative gateway to their career destinations. The number of technologists can also be enhanced by creating student-centered transfer opportunities of A.A.S. degree holders and Certificate holders.

References: