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The Development of a Global Worldview

Abstract

Several of the more open ended ABET Criterion 3 outcomes have the potential to significantly change engineering education. Unfortunately, these outcomes are difficult to measure and, as such, are not well understood. In particular, outcome (h), which states that graduates must demonstrate "the broad education necessary to understand the impact of engineering solutions in a global and societal context." This one outcome has the potential to impact student education more than any other. The importance of this topic is reinforced every day as engineering jobs are facing global competition. Industrial Advisory Boards are also suggesting that this internationalization of engineering education be emphasized more in the classroom. Young engineers need to develop strategies that can address the challenges presented by globalization. The globally-oriented engineer must understand others in terms of life perspectives, must learn how to interpret international events and circumstances, must explore how one interacts with the world and its environment, and must learn how to apply engineering methodologies to solve societal problems (i.e. clean water, energy, food, health problems, etc.). The paper will address some of the issues related to engineering in the global context and how Baylor University is approaching the integration of this subject through its curriculum and extra curricular activities (i.e. language requirement, interdisciplinary overseas summer school, classroom exercises, and appropriate technology studies/trips) and what is planned for the future (School Committee on Global issues, Advisory board activities, and Classroom Activities).

Introduction

The U.S. production of scientists and engineers has continued to fall in relative terms when compared to Asian rim countries.[1] For example, in 2005 Indian schools awarded approximately 112,000 engineering bachelors degrees, China 351,537, and the U.S. 137,431.[2] It appears that fears of "outsourcing", fueled by the growing availability of international technical labor and population demographics, has driven some U.S. students from high-tech programs; a trend that may be irreversible. The international business climate of the last decade has taught U.S. companies to think in terms of strategic partnerships and alliances to penetrate and expand markets. Considering the apparent irreversibility of market forces, engineering educators should consider how best to prepare students to participate and thrive in this new economic climate.

Only training engineers to be participants in the present global consumerist economy may be missing the mark. The events of the last decade have clearly pointed to the growing social and economic interdependence of previously independent societies. This fact is clear when one considers the impact of health issues related to HIV, SARS, and H5N1 in the presence of inadequate third world health systems or the impact of rising energy prices on the green revolution. A significant percentage of the world's food production is underpinned by agricultural mechanization and the use of fertilizers and chemicals; all of which are energy intensive. The implication being that the rising energy prices may soon translate into growing and endemic famine in many parts of the world.[3]

There is evidence[4,5] that within a decade there will be urgent global issues that may make the arms and space race, which absorbed a large percentage of the U.S. engineering efforts at the end of the 20th century, seem trivial. The complexity of these global issues will require greater and more sustained efforts by the global engineering community than it has been able to muster in the past. The U.S. engineering community could make significant contributions if we train young engineers to connect with their counterparts around the world to generate the ideas, vision and leadership needed to meet the future's challenges. Engineering educators should consider how best to prepare a globally aware generation of young engineers to be fully functional partners with their global peers.

The ASEE's *Green Report*[6] puts engineering education in an international context and urges that engineering programs respond with appropriate changes to their curriculum to "incorporate an appreciation of different cultures and business practices, and the understanding that the practice of engineering is now global." The National Academy of Engineering is also concerned that students are prepared for the future.[7] Their 2004 report[8] states that the "…economy in which we will work will be influenced by the global marketplace for engineering services, as evidenced by outsourcing of engineering jobs…" Re-engineering engineering education is proposed with the need for further research on learning. There is a need for the development of life long learning and specific skills which are able to adapt to global changes.

Assessment Driven Change

Many U.S. universities and colleges have undertaken significant curriculum reforms to address the issues related to our growing global interdependence. For engineering programs the process of assessing future needs and developing curricula is the heart of accreditation. Typically, the focus of engineering schools has been ABET's Criterion 3 – Program Outcomes and Assessment,[9] which deals with an engineering program's outcomes and what a successful graduate will be able to accomplish upon graduation. Of special interest in the present paper are Outcomes 3-h and j.

- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context (3-h)
- a knowledge of contemporary issues (3-j)

Simply distilled, engineers need an understanding of the social, cultural, political, and economic world. They need an understanding of the natural environments and ecologies that provide the resources that support human existence. They need cross-cultural contacts and experiences. And they need an understanding of the language of international communications in engineering and business. Engineering graduates must develop a perspective that will allow them to contextualize the changing world around them. The ability to inculcate such a perspective should be one characteristic of successful engineering programs; it will not be enough to equip engineering students with just the hard technical skills.

Baylor University's Efforts and Initiatives

International education is considered critical in the preparation of students for working and living in an increasingly global environment.[10] Over the past decade the number of U.S. students participating in a study abroad program has more than doubled.[11] The Institute of International Education reports that 5,462 engineering students studied abroad for the academic year, an 8.2 % change from the previous year. This is only 2.9 % of all students who studied abroad. Approximately 56% of all study abroad students studied for terms of less than a semester, indicating a rising trend among students for shorter time periods, perhaps a trend caused by the events of 9/11. An opportunity to study abroad gives students an enriching opportunity to experience different countries and different cultures, to interact with colleagues of different nationalities within their cultural contexts. This is especially true for students in technical disciplines, who do not typically have the time, the money, or the free electives in their degree plan for a study abroad program.[12]

The engineering curriculum at Baylor University contains an institutional language requirement, the legacy of Baylor's liberal arts emphasis. This requirement is to demonstrate a second-level proficiency in a language of choice. Many students with family or high school language proficiency gain advance placement or are able to receive credit by examination. If this is not the case, then the student must take two semesters of foreign language to gain the proficiency required by the University. As the only engineering program in the state of Texas to require language proficiency, the University believes that this requirement provides a dimension to a Baylor graduate that would not be available elsewhere and that is consistent with the University mission. Foreign language study makes the student more aware of other cultures and provides exposure to the global community in a way that the department of engineering could not do. Baylor students also participate in summer abroad experiences that give them an opportunity to use their language skills and experience another culture during their academic career.

The School of Engineering and Computer Science (ECS) at Baylor developed a summer study program, designed specifically for ECS students, to give them a chance to study abroad and experience different cultures and peoples. The program is designed to provide instruction that is pertinent to their degree plan, is affordable, and one that does not interfere with students' ability to take upper-level courses during the regular semester. Because of concerns that students did not have sufficient business acumen upon graduation, this program was tasked to include business issues. Students should understand how economics factor into engineering issues in today's global world, how the cost of living is dramatically different in developing countries, how the cost of doing business (resources, manpower, etc.) is very different in different countries, and how the cost of doing research and development, or the cost of ***not*** doing research and development, must be examined in the long term. In addition, the cost of lost revenue, the cost of loss of market share, and the cost of non-renewable resources, all must be carefully studied together because all these factors effect the decisions we make as engineers. For these reasons, the School partnered with Baylor's Hankamer School of Business to develop a six-week summer study abroad program for both ECS and business students, the Baylor International Technology Entrepreneurship (BITE) program.

The BITE program is a six-hour multi-disciplinary, multi-national project-based course. It covers a broad range of topics that critically affect technology-based companies and technology based start-up businesses. Primary emphasis is placed on the marketing concerns, intellectual

property issues, economic analysis, and business plan preparation for these technology based e-businesses. Other issues to be investigated include identifying venture opportunities, concept development, market analysis, pricing, budgeting, legal forms of organization, team management, and business valuation and dilution. The students apply this knowledge by preparing a business plan for a high-tech company; implementing a prototype of the web application that they develop; presenting their final product to private equity, venture capital, bank, and other sources of startup capital; and delivering a complete set of documentation to their client.

The course is project-based, where teams create and develop a business plan for a high-tech web-based business, and also develop a technology prototype. The participants are upper-classmen in engineering, computer science, and business, in good academic standing with their respective schools. The project teams are both multi-disciplinary and multi-national, with American students from Baylor University and Dutch students from the University of Maastricht participating in the project teams.

To give students international exposure in a non-academic setting, a group of ten students and three engineering faculty members made a trip to Kenya to look for opportunities to partner with local institutions. The goal was to find applications where appropriate technology could help the local communities. The group participated in the fabrication of a suspension bridge and the installation of an LED lighting system in a local building. The trip was very motivational for students and a second trip to Kenya is being planned for the end of the current spring semester.

The Department of Mechanical Engineering, in preparation of an upcoming ABET evaluation, has taken inventory of assessment tools used to evaluate the ABET Criterion 3 outcomes. In particular, the inventory found that there were several assessments being made which could be used in for outcome 3h. First, in the junior design course, students are given a writing assignment that requires students to research and report the key elements of an historical or contemporary impact of technology. One emphasis of this paper is the global impact of technology. A second writing assignment used for assessment is given in the basic thermodynamics class. Here the student is asked to write an essay on energy and the environment. A third opportunity for a student to be exposed to the impact of engineering solutions in a global and societal context is a short presentation required in the heat transfer class. Here such topics as energy generation and nuclear waste have arisen and prompted discussion in the classroom. While these three classroom assignments are addressing the topic, none of them is as intentional as they might be in increasing student awareness of global issues. More needs to be done.

One result of the assessment process was a recommendation to use the current technical writing class, ENG 3300 Technical Writing, to address global issues. Engineering, in the past, has enjoyed an excellent working relationship with the English department concerning topics for students writing assignments. Engineering faculty members participate as mentors and help students select topics and professional formats for reports. The proposal is for student to write on global issues in engineering. This avenue is being investigated with the English department.

The junior design course at Baylor University has addressed global issues on occasion. One semester, the students were asked to design a solar power system that could operate a water pump. This solar power system was constrained in several ways. It had to track the sun to obtain the maximum power available and it had to fit in a prescribed container. While few teams were able to successful complete the task, this project was rewarding because it was viewed as something relevant to the needs of the developing world. This is an important aspect to motivate student to become globally aware. More projects that attempt to solve some of the basic problems associated with the developing world should be developed; however, they must be discussed in the context of the culture and environment of the application. Far too often what is perceived as the answer to a problem can cause more problems in the long-term. Is the solution sustainable? How will the technology impact the culture and is that acceptable? Students should be made aware that technology alone is not the answer to all the world's problems.

Several student organizations exist which provide students with global experiences. Engineers Without Borders – USA[13] is such an organization. It is committed to designing and implementing engineering projects in developing communities around the world. It seeks partner with these communities to "improve their quality of life through implementation of environmentally, equitable, and economically sustainable engineering projects while developing internationally responsible engineers and engineering students." A large number of projects are undertaken each year which address specific needs of communities in the developing world, primarily issues of sanitation, safe drinking water, and economic needs. Another such organization is Engineering Ministries International.[14] This organization, in keeping with Baylor's historic Christian emphasis, is a non-profit organization that involves engineers who donate their skills to "help children and families around the world step out of poverty and into a world of hope." This organization has undertaken over 500 projects in 75 countries since 1982.

At Baylor, a similar organization, called Engineers with a Mission, has been established.[15] This organization seeks to serve developing communities by providing engineering services to support community development projects. The organization seeks to cultivate leadership and technical abilities in its student participants and foster a spiritual view of life as a calling to serve society and the world. Students are interested in this organization because it implicitly embodies Baylor's mission. Baylor University Ministries currently has three interdisciplinary trips scheduled for 2006 (Kenya, Armenia, and Honduras) to give students opportunities to participate in projects in the developing world[16]. The concern of engineers participating in these projects is that they often do not involve application of engineering skills; however, the positive benefit is that students are exposed to real needs outside of the academic environment.

Baylor has a Center for International Education,[17] which seeks to ensure the most positive experiences possible for international students and faculty, and to emphasize to the larger University community the contributions of internationals to the diversity and richness of the student body. The Center seeks to encourage the growth of tolerance, understanding, respect, and compassion by managing study abroad and exchange program opportunities for all students. By encouraging international opportunities for faculty and staff development, the Center also seeks to encourage the "internationalization" of Baylor University.

During the fall 2004 semester, 417 international students and scholars from 76 countries were present on the Baylor campus, and during the past academic year, 880 American Baylor students participated in Baylor's over 50 outgoing study abroad and exchange programs. Typically, one or two international students are enrolled in engineering at Baylor and three to five students participate in the study abroad program.

The ECS Board of Advocates and other constituents (alumni, industry hiring managers, etc.) have urged the School to help make our graduates even more distinctive and valuable by increasing their capability in areas such as understanding the international market place, appreciating global issues and cultural differences, and being able to communicate ideas with clarity, brevity, and persuasion. This year the Dean organized an ad hoc committee to investigate these possibilities and recommend curricular changes/additions that might meet the objective of preparing ECS graduates to respond to these challenges. The goal of this committee was to recommend alternative course sequences, without jeopardizing accreditation criterion, jeopardizing students' preparation for the Fundamentals of Engineering (FE) Examination, or adding additional hours to the current degree plans.

Their initial recommendation was to offer an alternative to courses in the engineering and computer science curricula that were initially created to satisfy ABET EAC/CAC accreditation requirements. For engineering, these courses include ECO 3308, "Engineering Economic Analysis" and ENG 3300, "Technical & Professional Writing." For computer science these courses include ENG 3300, "Technical & Professional Writing," and CSS 3308, "Technical Speaking." The alternative presented was a two-course sequence, "Business Basics for the Global Technology Professional," and "Technology Entrepreneurship in a Global Economy," which together would cover the essential instruction and in-depth practice of the substituted courses, but in a learning environment that challenges the students to apply what they have learned in a technology-based group project. It is hoped to implement this in a pilot program during the fall 2006 semester.

Conclusion

Now, more than ever before, engineering students must be made aware of the global aspects of engineering. The "soft" ABET Criterion 3 outcomes have the potential to significantly change engineering education, in particular, outcome (h). Engineering students must develop a global perspective and be able to adapt to the changes that are ahead. Engineering programs, guided by Industrial Advisory Boards, will be emphasizing internationalization of engineering education in the classroom. The globally-oriented engineer must understand others in terms of life perspectives, must learn how to interpret international events and circumstances, must explore how one interacts with the world and its environment, and must learn how to apply engineering methodologies to solve societal problems. Baylor University is making progress towards these ends with study abroad programs, appropriate technology projects, and changes to curricular requirements. At Baylor, ABET assessment of outcome 3h shows that, while the topic is being addressed in the curriculum, more intentional methodologies in the classroom must be developed. While study abroad programs exist at Baylor, more students need to be encouraged to participate.

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