

AC 2007-1991: GROWING GLOBALIZATION OF ENGINEERING PRACTICE: RAISING NATIONAL AWARENESS

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Growing Globalization of Engineering Practice: Raising National Awareness

Abstract

In this paper, we illustrate how a number of factors are driving the globalization of engineering practice, and we present the highlights of a recent survey that was conducted to better characterize the current state of international opportunities for engineering students, including the trends, general themes, and major exceptions.

1 Introduction

The value of an international cognizance, in the context of engineering education, has been the subject of much research. A recent study, *In Search of Global Engineering Excellence*¹, summarizes the large majority of these findings:

The ability to live and work in a global community is — today — an important requirement for engineering graduates. They need to have broad engineering skills and know-how, and to be flexible and mobile, and able to work internationally.

Regrettably, the fulfillment of this international cognizance within the United States has gone largely unmet. Study and work abroad programs are driven by the priorities and plans of an educational institution, and when there is cooperation among universities, it is usually only ad hoc at best.

There is, however, a growing realization of the inadequacy of the United States' approach. In this paper, we present how publications such as ABET's *Engineering Criteria 2000* and the National Academy of Engineering's *The Engineer of 2020* are bringing attention to globalization in engineering. Additionally, we offer the results of a recent non-scientific survey performed to help characterize how universities are attempting to increase their numbers of engineering students studying abroad.

2 Globalization in Engineering

As Friedman notes², the world is becoming flat – economic competition between industrial countries and emerging market countries can no longer be separated. As an example, India and China are rapidly entering the complex global supply chains, primarily due to the Internet.

A flat world requires American engineers to be capable of working in a global context, whether they find employment within the United States or internationally. This fact is becoming apparent throughout organizations within the United States, with national engineering organizations emphasizing the importance of learning outcomes and related skills development for engineering students. Below we present how ABET's *Engineering Criteria 2000* and the National Academy of Engineering's *The Engineer of 2020* are bringing attention to the need for globalization in engineering. Collectively, these publications have raised both awareness within the engineering

education community and awareness within the public on the importance of engineering students gaining an international cognizance.

2.1 *Engineering Criteria 2000*

ABET's *Engineering Criteria 2000*³ (EC 2000) are helping to raise the national awareness of the growing globalization of engineering practice. As an example of this growth, the *Proceedings of the 2005 ASEE Annual Conference and Exposition* listed approximately 25 papers addressing international activities, while the *Proceedings of the 2006 ASEE Annual Conference and Exposition* listed 50 papers of a similar nature.

Although EC 2000 does not specifically require an international experience for accreditation, there is little question that international experiences enhance a number of criteria:

- Criterion 3.c specifies that engineering programs must demonstrate that their students attain “an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political...”
- Criterion 3.h requires “the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.”
- Criterion 3.j calls for, “a knowledge of contemporary issues.”

An engineering program demonstrates that it meets these outcomes through various learning experiences within and complementary to the curriculum. International experiences typically encompass aspects of these outcomes. Using international experiences requires assessment of their learning outcomes, and this remains an active area of study. For example, the Iowa State University College of Engineering competency-based assessment program, described by Mickelson, Brumm, and Hanneman⁴, provides semester-to-semester feedback from students and employers engaged in cooperative education, and one of the competencies measured is “cultural adaptability.” Also the University of Rhode Island Colloquium on International Engineering Education⁵ reported on assessment of international programs by Georgia Institute of Technology through the International Plan initiative⁶, which emphasizes global competence. The assessment of international experiences is indicative of their growing importance to educating future engineers.

2.2 *The Engineer of 2020*

In 2004, the National Academy of Engineering released a report entitled *The Engineer of 2020: Visions of Engineering in the New Century*⁷. This report attempts to forecast future conditions for an engineer in 2020, given current facts and trends.

The report makes a number of important conclusions stating that the engineer of 2020 must be internationally cognizant. Paralleling *The World is Flat*, *The Engineer of 2020* states (p. 51)

Advances in communications, travel, and economics have created a world where no country is untouched by any other. In the United States the oceans that bound our coasts no longer insulate us from other nations. In this dynamic global economy and political environment, engineering must adjust to a new world view.

We aspire to a future where engineers are prepared to adapt to changes in global forces and trends and to ethically assist the world in creating a balance in the standard of living for developing and developed countries alike.

Perhaps most importantly, *The Engineer of 2020* concludes (p. 56) with the fact that an engineer in 2020 must be flexible and capable of operating in a world where “social, cultural, political, and economic forces will continue to shape and affect the success of technological innovation” (p. 53):

Given the uncertain and changing character of the world in which 2020 engineers will work, engineers will need something that cannot be described in a single word. It involves dynamism, agility, resilience, and flexibility. Not only will technology change quickly, the social-political-economic world in which engineers work will change continuously. In this context it will not be this or that particular knowledge that engineers will need but rather the ability to learn new things quickly and the ability to apply knowledge to new problems and new contexts.

3 Survey

Stemming from a recent paper⁸, we wanted to better characterize the current state of international opportunities for engineering students, and qualify how universities are growing globalization of engineering practice. In order to do so, a non-scientific survey of approximately 300 United States engineering programs⁹ (with approximately 15% response rate) was performed. The following questions were included in the survey:

- 1) Does your college believe that an international experience for undergraduate students is important? If so, why?
- 2) Do you have one or more programs for undergraduate students to increase their international knowledge/experience?
- 3) If you do have such programs,
 - a. What was the motivation for creating them?
 - b. Please give a brief description of the programs.
 - c. Do you have any information that addresses the effectiveness of any of your programs?
- 4) Approximately what percentage of your undergraduate students will have had an international experience by the time that they graduate?

4 Survey Results

Of the survey responses, there were a number of interesting answers. Below we present our findings, organized by question.

4.1 *Question 1 – Does your college believe that an international experience for undergraduate students is important? If so, why?*

Of the responses, all universities acknowledged that an international experience is important for undergraduate students. The reasons paralleled the same general concepts discussed above in the section on Globalization in Engineering.

Specifically, the University of Cincinnati and the University of Maryland, Baltimore County acknowledged that the world is becoming flat. In fact, *The World is Flat* was required reading for all of the University of Maryland's juniors last year.

At West Virginia University, much of the support for international programs comes from international faculty members and faculty members who themselves have had rewarding international experiences. Iowa State University stated that faculty support for international programs carries much importance, since in many cases, faculty add credibility to the programs.

To help faculty members gain international experiences themselves and to forge partnerships at international universities, Pennsylvania State University provides faculty travel grants. These travel grants are used for a number of purposes, including supporting activities and exchanges, helping faculty acquire further funding for international programs, and assisting faculty who want to develop material for courses that have international components. Since faculty carry much weight in the success of international programs, this appears to be a very good idea. *In Search of Global Engineering Excellence*¹ agrees in that “barriers to studying, working, conducting research, and attending meetings internationally need to be removed and incentives expanded.”

Faculty support for international programs raises an important point: many times the initiative for international experiences begins at the administrative levels. As an example, Michigan State University's President made study abroad a priority ten years ago. Currently, Michigan State claims to have the largest study abroad program in the country. Similarly, the Iowa State University College of Engineering Strategic Plan indicates that “[the university] will prepare [its] students to become leaders in a profession dominated by globalization.” As another example, the faculty at the University of Iowa endorsed a vision statement “embracing a college-wide commitment to global awareness.” *In Search of Global Engineering Excellence*¹ echoes similar ways forward in that “universities should make international preparation a priority in their institution's strategic plans and actively pursue it.”

In summary, each college that replied said that an international experience is important to their undergraduate students; however, a few schools indicated that a lack of faculty support and/or financial conditions make it difficult or impossible to have a meaningful international program.

4.2 *Question 2 – Do you have one or more programs for undergraduate students to increase their international knowledge/experience?*

About 15% of the schools that replied rely on their own university-wide study abroad offices for providing international experiences. The others either had their own engineering-specific study abroad programs, or did not have international programs at all.

The number of universities that do not provide study abroad opportunities is small, but they do exist. Reasons cited state that it is sometimes difficult to encourage study abroad among minorities and students in engineering.

It is important to realize that although it may be difficult to encourage study abroad among students, especially in these early stages of raising national awareness, the opportunity for a student to gain an international experience must at least exist. Universities such as the Colorado School of Mines and the University at Buffalo are participating in the Global Engineering Education Exchange¹⁰, which immediately connects a university into a 17-country study abroad network.

Dessoff¹¹ argues that one of the main reasons why science and engineering students are not studying abroad is because of the rigid curriculum required in engineering that offers little “wobble room,” when compared to students in the humanities and social sciences. Stanford University agrees, stating that the sequencing of courses makes it difficult for engineering students to fit in a study abroad.

*In Search of Global Engineering Excellence*¹ realizes the need for flexibility when it comes to international experiences: “Universities and engineering programs need to develop more flexible approaches to their educational programs.” The University at Buffalo acknowledges that in addition to faculty and financial support, encouragement has come from the ability to create and operate flexible programs.

In summary, about 15% of the schools rely completely on university-wide international programs and have no engineering specific programs. It is also clear from the responses that in many cases the engineering international programs are new and/or rapidly expanding.

4.3 Question 3.a – What was the motivation for creating them?

In addition to the general concepts discussed above in the section on Globalization in Engineering, universities have created international programs for a number of reasons. As a few examples, one of the reasons the University of Notre Dame has international programs is to provide students the opportunity to study abroad. One of the motivations for the University of Wisconsin-Madison was to help counter the under representation of science and engineering students in study abroad programs. Finally, the University of Virginia cited student/parent demand.

Another important motivation for international programs, as noted by Georgia Institute of Technology and the Olin College of Engineering, is the opportunity for students to enroll in courses not available at an institution, or courses that would be impossible for an institution to replicate.

In summary, the motivations for creating international programs are numerous: they range from the need for engineers to be internationally cognizant to the chance for students to partake in an educational experience that cannot be replicated.

4.4 Question 3.b – Please give a brief description of the programs.

In addition to the study abroad, summer abroad, and work abroad programs that many universities offer, a handful of responses discussed programs that are more unique. As an example, some universities, such as the University of Texas at Austin and Texas A&M University, offer faculty-led programs at host institutions abroad. These programs involve a faculty member from the home institution teaching, and sometimes co-teaching with a faculty member from the host institution, a class of the student participants abroad.

The University at Buffalo offers this faculty-led approach as a five-week summer program for freshman students. In addition to helping younger students adjust to an international experience with a familiar faculty member, the students are provided this opportunity early in their college careers when they would usually not yet have enough experience for internships and other experiential education opportunities.

With regards to research, a number of the respondents discussed international research and/or team-based collaboration opportunities. The University of Iowa and Harvey Mudd College operate one-year programs that involve students participating in substantial electronic communication with and travel to partner institutions in order to collaboratively solve problems. Cooper Union students can participate in an eight-week summer research program at partner institutions in Europe and Asia, and reciprocally, qualified students from these institutions can choose to come to Cooper Union for a semester study abroad.

At the Colorado School of Mines, a thesis-based dual degree program at the Masters level exists to help motivate graduate students to study abroad. Masters students in this program work in a unique, collaborative environment, in that faculty and students collaborate to support the same research.

The University of Maryland, Baltimore County (UMBC) offers a two-year program that bridges undergraduate and graduate programs. Specifically, a student from Porto University in Portugal comes to UMBC during his or her senior year to build a research base, and returns to Porto University to finish his or her undergraduate education. The student then returns to UMBC for his or her Masters degree. The goal was a similar exchange of UMBC students, but UMBC reports that a limited number of students going to Portugal. We speculate that partnerships of this type, at least at first, would enjoy more success with partner universities in English-speaking countries.

With regards to industry and work experiences, West Virginia University offers a six-week summer program in Mexico in which West Virginia students team up with students from Mexican universities. The team of students then completes a meaningful, industrial project under the supervision of Mexican instructors and professionals in industry. The immersion is complete, since students work full-time and live with local families.

In addition to study and work abroad opportunities, international courses at United States institutions can provide a better understanding of globalization through either one class or a series of classes. Pennsylvania State University offers a series of courses, whereas the University of Iowa offers a seminar series in which corporate, government, and academic leaders

present their perspectives on internationalization. In addition, Iowa State University offers a graduate-level course on the globalization of technology and culture. *In Search of Global Engineering Excellence*¹ supports the need for international coursework:

It follows, therefore, that engineering curricula must instill this global mindset. At least three elements are believed to be needed to produce globally competent students: coursework in international studies, second language proficiency, and international experience.

Degree add-ons, like an International Engineering Certificate, are used to show completion of international requirements, e.g., a study abroad experience or international coursework. When awarded on a transcript, this gives students further motivation and reward for international experiences; certificate-based programs can be found at a number of universities, including Pennsylvania State University, the University of New Mexico, Duke University, the University of Michigan, and Texas A&M University.

Moreover, cooperation between colleges within a university has been shown to be successful in creating further international opportunities for engineering students. As an example, the University of Michigan combines a traditional undergraduate engineering curriculum with courses in business and international culture through the business and literature, science, and arts schools, respectively. Michigan says that this type of training is in high demand, stating that graduates from this program are highly sought after by companies worldwide. In the same way, Pennsylvania State University and Iowa State University offer programs that allow their engineering students to concurrently pursue majors in engineering and a foreign language. These efforts are also achieved at each university through inter-college cooperation.

Many universities mentioned the lack of funding available with international programs. Although funding is a concern, it should be noted that Cooper Union has just been awarded support from the NSF for its program in Ghana. Specifically, Cooper students and faculty have helped develop laboratories and courses at a university in Ghana. Additionally, other Cooper students have helped with infrastructure projects at towns and hospitals.

Finally, the importance of student volunteer programs should not be underestimated. At Iowa State University, a student volunteer program called the Society of International Engineers (SIE) provides hospitality to exchange students studying at Iowa State, encourages participation in international exchange programs among students at Iowa State, and promotes international engineering programs to prospective students. In addition to providing students leadership opportunities, SIE benefits from the large amount of student energy in promoting study abroad at Iowa State.

In summary, there are a wide variety of international programs in place at universities throughout the United States. Programs that are more unique involve faculty-led programs, research opportunities, graduate programs, team-based work experiences, and international coursework.

4.5 *Question 3.c – Do you have any information that addresses the effectiveness of any of your programs?*

After an international experience, many schools administer informal follow-up surveys that are highly anecdotal in nature. A “real” assessment, as Michigan State University claims, is “a bit of an elusive goal.”

Although most current information is anecdotal, it should be noted that the feedback is strong. Participants are often overwhelmingly enthusiastic, with one student at Boston University claiming that his or her international experience was “...the greatest experience of [his or her] life...”

The University of Southern California and Stanford University agree that an international experience is life changing, with many students at Stanford saying that study abroad is one of the most important things in their college careers. USC also states that a number of students who participate in international programs will seek employment with companies that have international opportunities.

With respect to what was discussed earlier in this paper, Mexican government agencies have sent West Virginia University letters on the impact and success of their program. Additionally, students at the University at Buffalo who participated in the freshman program, when compared to those who did not, were more likely to study abroad later in their college careers.

Finally, the University at Buffalo makes the interesting point that although an international experience may not be necessary for an entry-level position in engineering, international experience becomes a bigger consideration at the management level, especially in companies that are engaged internationally. Similarly, alumni have reported back to West Virginia University stating how international programs have helped their professional development.

In summary, only a few of the respondents have any formal approach to evaluating the effectiveness of their programs, although almost all reported strong anecdotal feedback from students who had had an international experience.

4.6 *Question 4 – Approximately what percentage of your undergraduate students will have had an international experience by the time that they graduate?*

The survey indicated that less than 14% of United States engineering undergraduate students have had an international experience by the time they graduate. However, as stated earlier, it is also apparent that many engineering international programs are new and/or expanding rapidly.

5 Conclusions

It is clear that research with respect to the globalization of engineering is just beginning. According to *In Search of Global Engineering Excellence*¹, “research on engineering in a global context is urgently needed,” and much work remains to be done.

As *Engineering Criteria 2000* and *The Engineer of 2020* are promoting the globalization of engineering practice, we must continue to search for new ways to enhance international engineering education within the United States. According to the American Council on Education¹²:

We need to continue to look for new ways to internationalize undergraduate curriculum and to enhance and expand the teaching of foreign languages, especially languages that are critical in the global economy and the U.S. position in the world.

Moreover, the results of our survey indicate that universities recognize the need for an international cognizance among engineers they train, and many efforts are being made to incorporate international experiences into their engineering curriculums. With additional research, these efforts will continue to mature giving American engineering students more opportunities to incorporate international experiences into their educational programs.

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