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Developing Global Engineering Outcomes for BS Graduates

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Developing Global Engineering Outcomes for BS Graduates

Abstract

Producing globally competent engineers for the 21st century is increasingly important in a world that is "flat" and more globally connected. Schools of Engineering across the country are responding to this need. The University of Portland (UP) recently elevated its efforts to promote global experiences for its engineering students after the faculty, in May 2012, endorsed a goal that 50% of graduates will complete an international experience by 2017. Across the last seven years, approximately 20% of engineering graduates completed an international experience of varied durations, with the percentage increasing from 13% in 2008 to 23% in 2014 as we added new programs that include traditional study abroad as well as international experiences through service, capstone projects, elective courses, and research opportunities. Having established School targets, we recognized that not all global experiences are created equal with respect to cross-cultural awareness, exposure to global engineering practice, or the development of skills for living and working in different cultural contexts. Because of the wide disparity of experience that can be achieved from various global programs, the UP faculty completed a process to define the outcomes for our students with respect to global engineering. Over the last year, a School committee reviewed the relevant literature, evaluated existing and planned programs, and met with various stakeholders including several of our alumni who have significant global experience, as well as our international partners (China and Austria). Faculty then reviewed the proposed outcomes and approved them in Spring 2015. There are three major sets of outcomes. The first two address general global literacy for the entire university and represent the ongoing work of a University-wide committee. The third outcome addresses the global literacy needs of professionals involved with global engineering. To support achieving these outcomes, the School also approved several best practices to guide the development and improvement of relevant engineering programs.

Introduction

Producing globally competent engineers for the 21st century is increasingly important in a world that is "flat" and more globally connected. Engineers are now facing the distinct possibility that they will be working for a multinational company, or NGO that requires multicultural awareness, some degree of foreign language proficiency, and the ability to communicate effectively across cultures and time zones. However, data from the Institute for International Education show that few US science and engineering majors complete a study abroad experience; engineering represents three percent of all US study abroad students while computer science is at 1.5 percent.[1] Notwithstanding the significant resources often needed to promote study abroad, there are several other factors that affect the ability of institutions to promote globalization outcomes for students. For example, several universities are revamping their core curriculum to include an emphasis on globalization while others are creating interdisciplinary courses with an international "thread" linking subject content from disciplines as diverse as fine arts, social sciences, natural sciences, and economics.[2]

Schools of Engineering across the US are also responding to the need to help their students be better prepared for the global economy resulting in several institutions, both public and private, sending substantial numbers of engineering students overseas for a variety of programs. Some examples include:

- Georgia Tech University, the largest engineering school in the U.S., states that 46% of their undergraduate students have participated in one of the school's international programs.[3]
- All Rensselaer Polytechnic Institute students are encouraged and expected to take advantage of some sort of international experience during their four-year undergraduate education.[4]
- University of Rhode Island students can complete a 5-year dual degree program of engineering and foreign language.[5]
- Nearly 66 % of engineering graduates at Lafayette College (2104) studied abroad while staying on track to graduate in 4 years.[6]
- Starting with the fall 2013 entering class, all undergraduates at Texas Tech University are required to have an international experience.[7]

In this paper, we first provide the background for globalization initiatives within the Shiley School of Engineering (Shiley School) at the University of Portland. We then describe the process we used to develop global learning outcomes for engineering and computer science students at the undergraduate level. We conclude with some ideas for how to assess these outcomes over the long term.

Background

Based on seven years of available data, approximately 20% of engineering graduates completed an international experience of varied durations, with the percentage increasing from 13% in 2008 to 23% in 2014. At the May 2011 planning meeting, the Shiley School faculty endorsed an aspirational goal of 50% of graduates completing some type of a global experience which has led to a focused effort to develop a suite of global options for engineering students.

Study abroad at the University of Portland (UP) has its roots in a year-long Salzburg Program which celebrated its 50th anniversary in 2014. The University leases a small campus in Salzburg Austria and most of its study abroad programs are based at that location. Since 1963, the number of study abroad programs at the University has continued to increase with the addition of semester and six-week summer programs in a variety of venues ranging from Western Europe to Latin America and Asia. These programs focus on either foreign language instruction, or the University's liberal arts core curriculum courses. Engineering students occasionally participated in these programs over the years, however, the typical semester and year-long programs extended their time to graduation beyond four years.

In the summer of 2006, the University launched the first six-week program dedicated to

engineering students at the Salzburg. Campus. This summer program has been offered every other summer through 2012 and then, due to student demand, we switched to offering the program every year. A cohort of between 15 to 25 students from across the engineering majors completes two courses during the six weeks, a core curriculum liberal arts course and either engineering statistics or engineering economics. The latter engineering courses are required for all of the engineering majors and can be taken as an elective by the computer science majors. The students are typically rising juniors though we occasionally allow rising seniors and rising sophomores to participate. An engineering faculty member accompanies the cohort and several technical and cultural excursions are included in the experience.

In the spring of 2013, the first cohort of three engineering sophomores participated in a Madrid semester program operated by a third-party provider and designed for engineering students. Five more sophomores participated in the program in spring 2014 however, due to financial reasons and some curricular incompatibility, the University stopped supporting this program. To replace the Madrid option, the University allowed the Shiley School to use eight places in what is normally a year-long Salzburg program to launch an engineering semester program. A pilot of this program began in spring 2015 with full implementation expected in spring 2016. The Salzburg engineering semester program represents a partnership between the University's main campus in Portland and its Salzburg campus, along with the University of Applied Sciences Upper Austria (Wels campus). Sophomore mechanical and civil engineering students complete two core curriculum liberal arts courses, as well as a German language course at the Salzburg campus where they live and participate in the various cultural programming. They travel to the Wels campus to complete two required engineering courses that keep them on track for a four-year graduation. Faculty members at the University's main campus in Portland provide distance-learning modules to supplement the engineering courses.

Starting in Summer 2013, the Shiley School of Engineering supported several additional international experiences. One is a partnership with the Rijksdienst voor het Cultureel Erfgoed (Cultural Heritage Agency of the Netherlands) that allows two mechanical engineering students to complete summer undergraduate research projects at the intersection of art and engineering in Amsterdam. Another is a University-wide program on service-learning in East Kenya that allows at least one engineering student to complete a project related to his or her major for a rural community; typically these are clean water and sanitation projects that appeal to civil engineering students. We have also supported several senior capstone projects with an intercultural component including some with a travel experience. Finally, in spring 2015, the Shiley School started offering an elective, EGR430 Global Engineering that includes an international immersion in China over spring break and is based on material developed by faculty at Purdue University, Colorado School of Mines, and Virginia Tech (with permission from Dr. Brent Jesiek).[8]

Setting Outcomes: Feedback from Industry & Global Partners

In addition to setting targets for global experience and developing more programming and opportunities, the Shiley School faculty recognize that not all study abroad programs and international experiences are created equal with respect to the cross-cultural awareness,

exposure to global engineering practice, or the development of skills and mindset for living and working outside of the USA. A recent article in the Chronicle of Higher Education summarizes a research study indicating that the study abroad benefits for students depend on duration and destination of travel, therefore requiring intentional strategies to achieve the desired outcomes.[9] As an example, based on anecdotal observations made by students who have participated in our various study abroad programs, the Madrid engineering semester program includes a rich cultural immersion where students acquired more global survival skills than students in the summer Salzburg engineering program. Likewise, students who participated in a one-week senior capstone trip to collect field data did not experience the same level of global exposure as students in the six-week Amsterdam research experience, or the East Africa service-learning program.

Because of the disparity in experiential learning and cross-cultural awareness that can be achieved from various international programs, the Shiley School formed a Global Outcomes Committee that spent three semesters between fall 2013 and spring 2015 developing a set of learning outcomes for engineering and computer science students with respect to global engineering. The committee included the associate dean, the faculty director for international programs in engineering, two other faculty members, the School's academic counselor, and a student, and its charge was to develop outcomes that will be used to:

1. Guide the development and assessment of current and future global programs for engineering students, including study abroad, research and internships, as well as service learning, capstones, and immersion experiences.
2. Provide a set of criteria for awarding financial aid, or other forms of School support to engineering students wanting to participate in international experiences.
3. Establish a framework for the development of new courses, certificates, or minors in global engineering.
4. Position the School for the engagement in related, national STEM initiatives.
5. Strengthen the School's ability to compete with peer institutions in recruiting students.

The committee process included the following:

- Complete an extensive literature review.
- Consider the proposed University-wide outcomes addressing global literacy cross the campus.
- Develop a preliminary proposal to present to the Shiley School's faculty and obtain feedback in small group settings.
- Obtain feedback from the Shiley School's advisory council, comprised of approximately 20 senior engineers in a variety of engineering sectors.
- Meet individually with particular alumni who have extensive global experiences as part of their career.
- Meet with our international partners in China and Austria who are helping institutions to develop student programs.
- Combine the feedback into a refined proposal to present to the Shiley School faculty for discussion and vote. This affirmative vote occurred in January 2015.

Throughout the process, the engineering faculty's primary concerns were that a) inclusion of global engineering into the curriculum may dilute technical competency, and b) such programming will require additional resources. Feedback from the various stakeholders including alumni served to alleviate concern a). In terms of concern b), the Committee scaled back the initial proposal that included some additional programming and instead focused the final proposal on the outcomes themselves.

Members of the Shiley School's advisory council strongly endorsed efforts to incorporate global engineering into the curricula. Specifically, they noted that incorporating a global focus in the engineering student experience:

- Reinforces the breadth of engineering knowledge. The Council emphasized that University of Portland's competitive advantage over the larger engineering schools has been that we graduate students with a breadth of knowledge in addition to technical depth, i.e., the University of Portland develops "T-shaped" engineers[10]. Council members noted that the competition for graduate placement is no longer local, but is now global.
- Promotes student development of global competencies that will enable our graduates to work more effectively on cross-cultural teams. The Council emphasized that this sill is highly valued for engineering employers.
- Enhances capacity for personal and professional growth for our graduates, as well as their career mobility.
- Is integral to engineering and is "not icing on the cake" and "should not be an elective anymore."

The Shiley School's advisory council also suggested various considerations as the School develops more global opportunities, as follows:

- Provide opportunities for multiple experiences with a range of options to cater to different student motivations.
- Promote language proficiency (note: the Council differed in regards to this suggestion).
- Consider the countries that are having the biggest impact now e.g., Asian countries.
- Consider partnering with other universities regarding senior capstones.
- Find ways to overcome several barriers including a) being "late in the game" to global engineering, b) program costs given student demographics, and c) the Oregon (Pacific Northwest) mindset that results in students who are not as receptive to leaving the region.

The individual meetings with select alumni and our international partners in Austria and China aligned with the thoughts from the Shiley School's advisory council, and yielded the following more detailed feedback regarding what may be most important when preparing BS engineering graduates for global engineering:

- While the engineering process flow (e.g. engineering design, supply chain management, product development) remains the same, cultural differences may affect the timing of each step with more emphasis on some steps versus others. E.g., the testing phase may take more time in some countries versus the design phase versus the framing phase, etc.

- The environment within which engineering is conducted is changing with more cross-functional teams that are often completing the various steps in the engineering process across several countries within a 24-hour work cycle.
- Team dynamics, particularly in terms of communication, may be affected by cultural norms and the technology associated with virtual teams.
- Engineering principles never change, but the context within which engineering challenges exist differs by geography, culture, etc., and this affects problem framing, design. constraints, and deliverables.
- Most people will feel some discomfort when working in a different cultural context. The ability to experience that successfully, often with some guidance, leads to more confidence over time that translates into increased global competency.

The combination of feedback from the industry advisory council, alumni, and global partners, align very well with the learning criterion for global competency that was published by Downey et. al. in 2006[11] This criterion states that "*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*." (p. 110)

The Learning Outcomes

Based on this extensive feedback, the School adopted three learning outcomes in January 2015, along with performance metrics. The first two outcomes addresses general global literacy for the entire university, and are based on work in progress by a University-wide committee. These two outcomes may change as that process continues, however the Shiley School faculty agreed that we should align with the University vision for students' global literacy that will likely be incorporated into the core curriculum at some point in the near future. The third outcome addresses the specific global literacy needs of engineering students based primarily on the consultation with industry professionals. The global learning outcomes along with performance metrics for the Shiley School says that students should:

1. **Demonstrate knowledge of their own and another culture in a global context:**[1]
   a. identify significant factors in their own and another culture
   b. describe global impacts and effects of these factors
   c. compare their own cultures to another in a global context

2. **Interact successfully and appropriately with people from different cultural backgrounds:**[1]
   a. demonstrate awareness of intercultural social conventions and morays
   b. demonstrate curiosity about a culture different from their own by asking or interviewing and/or through scholarly inquiry

3. **Be prepared to practice engineering or computer science in a global environment:**
   a. understand how engineers from different cultures approach problem definition

[1] Draft University outcomes.

and problem solving

b. understand how cultural, political, legal, and environmental nuances, as well as unique regional design constraints and processes impact engineering on a global scale

c. successfully communicate internationally

Since the Shiley School is in the early stages of developing a focused global initiative, we also adopted specific guidance about the structural elements that should be considered as we develop new programs and/or modify existing programs. In other words, to achieve the global outcomes for our engineering students, designated Shiley School global programs should generally:

- include a significant intercultural experience at the college level
- immerse students into one or more cultures different from their own
- allow students to experience situations where they feel discomfort, adapt to this discomfort, and feel more confident about being put in similar situations
- require students to demonstrate a level of language proficiency appropriate to the type of experience

We have started to use these guidelines to develop the global engineering elective course piloted in spring 2015 and the engineering semester program in Austria. And, we expect to continually improve our other existing programs, primarily those available in the summer, based on this work. That said, we realize that we have not yet fully tackled how to systematically assess these outcomes. The other limitation with our work to date is that currently, we can only expect a small fraction of our students to attain these outcomes based on both demand and supply. And, we still need to expand our programming outside of Europe to the global regions that are "engineering" test beds. Our challenge is to provide more opportunities that are cost-effective while motivating our students to take advantage of them. As an example, we hope to have several exchange students from the University of Applied Sciences Upper Austria at the University of Portland (main campus) in fall 2015 as part of our exchange agreement that allows our Salzburg students to take their engineering courses in Wels. We are exploring how we can incorporate those students into our year-long senior capstone projects that will then continue "virtually" when they return to Austria. Similarly, we are hoping to use our experience teaching the global engineering elective to develop more engineering and computer science courses that embed global dimensions into disciplinary-specific content. In terms of this latter approach, such a strategy may help us overcome not just the cost barrier, but the mindset barrier for our students by allowing students to "*practice and hone skills at advanced levels and that they can learn to use them within the context of their future professional work*."[12]

Discussion

With the establishment of global outcomes in the Shiley School, study abroad initiatives, international REUs and internships, as well as new courses can be intentionally developed to achieve these outcomes at different levels. As previously mentioned, we have a new Salzburg engineering semester program and some of the outcomes proposed in this document guided its

creation, such as having engineering students complete courses at University of Applied Sciences Upper Austria rather than at the University of Portland's Salzburg Center while supplementing those courses with distance-learning modules and requiring that the students study some German. Similarly, the spring 2015 elective course was guided by all three outcomes in terms of not only the course content, but the experiences during the China immersion. In particular, student teams are working on projects that require them to identify and interview technical professionals or customers while in China in partnership with local Chinese business and engineering students, participate in technical plant tours, and complete a community service project.

With the establishment of these global outcomes, the next step is to develop a robust assessment method, review and improve our current programs, and develop new programs with the intent of achieving these outcomes at different levels and attracting more students. We expect to rely on national tools such as AACU's value rubric for Intercultural Knowledge and Competence[13] and the Intercultural Development Inventory[14], along with validated tools developed by various engineering education researchers in this field.

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