AC 2008-862: EXTENDING OUR REACH: WHAT WE HAVE LEARNED IN TWO YEARS OF ENGINEERING STUDY ABROAD PROGRAMS

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Extending Our Reach:
What We Have Learned in Two Years of Engineering Study Abroad Programs

Abstract

Two years ago the Ira A. Fulton College of Engineering and Technology at BYU embarked on an ambitious program to develop engineering study abroad programs. As a first step, we studied programs around the country to better understand programs formats and best practices. For the 2006/2007 school year, we sponsored seven student programs that involved sending students to China, France, Mexico, Romania and Tonga. In this paper we discuss what we have learned from the first cycle of these programs. Issues discussed include why we chose a particular program format, what went well and what did not, preparation of students beforehand, refinement of outcomes, and a surprising emergence, to us, of the potential and importance of international humanitarian projects.

Introduction

Engineering is a global enterprise. As perhaps no other work or study has done, Tom Friedman's bestselling book *The World is Flat* has brought into focus the remarkable changes that have reshaped the roles and skills needed for engineers in the 21st-century.[1] The changes that are transforming engineering and technology include the ability to communicate in real time anywhere in the world, the prominence of international markets, the development of global product supply chains, the shift to offshore manufacturing, the scale and reach of multi-national corporations, and the emergence of highly skilled engineering workforces around the world.

As one example of these changes, consider the development of the Boeing 787 "Dreamliner." This plane represents the most successful introduction of a commercial jetliner for Boeing, with over 700 orders received from customers in 32 countries. Fig. 1 shows where parts of this plane will be manufactured.[2] It is clear from this figure the 787 will be a globally developed and manufactured product, with major subassemblies of the plane coming from the United States, Canada, Italy, Korea, Australia, Japan, England, Sweden and France.

What does this mean relative to the desirable set of skills for engineers? Recently Patricia Galloway, former president of the American Society of Civil Engineers, addressed this topic in her important book, *The 21st-Century Engineer, A Proposal for Engineering Reform,* where she wrote, [3]

> A solid understanding of globalization is key to an engineer's success in today's global society. Globalization involves the ability to understand that the world economy has become tightly linked with much of the change triggered by technology; to understand other cultures, especially the societal elements of these cultures; to work effectively in multinational teams; to communicate effectively—both orally and in writing—in the international business language of English; to recognize and understand issues of sustainability; to understand the importance of transparency while working with local populations; and to understand public policy issues around the world and in the country

in which one is working. It will be these fundamental capacities that will enable 21st-century engineers to develop into professionals capable of working successfully both domestically and globally, highly respected by the general public and regarded by governments the world over as professionals of the highest order.

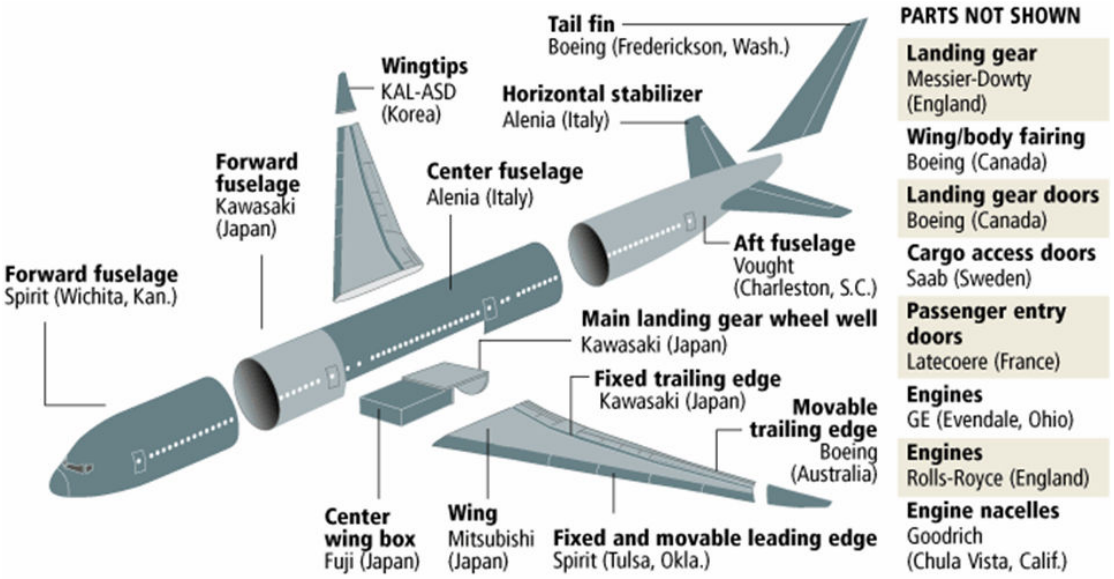

Fig. 1. Subassemblies of the Boeing 787 showing company and country of origin. Used by permission.[2]

As part of an effort to address these challenges, the Fulton College of Engineering and Technology at BYU began two years ago to implement technical study abroad programs. The first step for the college was to study other programs across the country in order to determine the types of programs in existence, and the challenges and best practices associated with these programs. Approximately 25 programs were reviewed and a number of exemplary programs were studied in detail.[4] The next step was to "take the plunge" by running our own programs. As part of an overall strategy to prepare our students, [5] the college decided to move ahead aggressively by sponsoring study abroad programs in China, France, Romania, Mexico and Tonga, a BYU led design project involving student teams in ten countries, and international internships. In this paper we will discuss what we learned from running these programs this past year. In particular, we will discuss the strengths and weaknesses of the various formats, the challenges that arose, and changes we intend to make in the future. As might be guessed, we had some surprises; in particular we had not anticipated that humanitarian projects would emerge as an important focus of the college.

Description of BYU Programs

Program Formats

In previous research, we identified different kinds of program formats for engineering study abroad programs.[4] To provide context for the discussion which follows, we summarize those formats in Table 1 below. These formats are not all inclusive; some programs cut across more than one format.

Table 1

Format	Description
Dual degree	Students obtain two degrees—one from the home university and one from the abroad university. Students follow an integrated program which includes substantial study at the abroad university in the abroad language. This format often is employed for graduate-level work.
Exchange	Students from the home and abroad university are exchanged and take regular courses in the abroad language. A parity of exchange is maintained so there is no net expense to either institution.
Extended Field Trip	Students take a 1-3 week tour visiting several countries, companies, and/or universities. Students obtain a "snapshot" of the world via a broad exposure to numerous places.
Extension	The home university operates a pseudo-extension campus in the abroad country at some sort of permanent facility. Courses are usually taught in English by faculty from the home university.
Internship or Coop	Students work abroad at a foreign company or at an international branch of a U.S. company. Often less structured than coursework, an internship can include a lot of informal learning regarding business issues, teamwork, communication, design, manufacturing, etc.
Mentored Travel	Under the guidance of a faculty member, students travel to the abroad country and study and/or tour for four or more weeks. Students stay together as a group. Many traditional study abroad programs would be of this type.
Partner Sub-contract	The home university partners with an abroad university and contracts for courses to be taught to students of the home university (usually in English). Students may live on-campus. Unlike an exchange program, parity of exchange does not have to be maintained.
Project Based Learning/Service Learning	Students travel abroad and are immersed in another culture via a project that connects technology with the abroad society. There has also been growing interest in programs such as Engineers Without Borders, which provide service learning via humanitarian projects
International Design/Capstone Projects	International experiences are integrated with departmental senior design/capstone programs. In this model groups of students are assigned projects that have international content.
Research Abroad	Students travel to an abroad laboratory and conduct research under the guidance of a faculty member or post doc, etc.

BYU Programs in 2007

In 2007, about 85 students participated in seven different study abroad programs. These programs included a mentored travel program (China), an extension program (France), an extended field trip program (Romania), two service learning programs (Mexico and Tonga), an international design project (ten countries), as well as several internships (China). We will discuss these programs in more detail.

China

The mentored travel program in China took place over six weeks. Based on preliminary work by two faculty members who visited a number of Chinese universities to better understand options, we decided to partner with Nanjing University. Nanjing, with whom BYU already had a relationship, was willing and able to provide lodging, classrooms and instructors for visiting students. Students participating in the program took one of two classes taught by Nanjing faculty, Business Chinese (for those students who already had some Mandarin proficiency) or Beginning Chinese. In addition, all students took a course entitled "Globalization, Engineering and

Technology" taught by the BYU professor who directed the program. As part of this course, students completed projects on some element of globalization that interested them. Courses were augmented with visits to engineering companies and cultural sites in Shanghai, Beijing, Nanjing and Xi'an. Photographs of this group are shown in Figs 2 and 3.

Fig. 2. Students at Nanjing University in China taking classes

Fig. 3. Students on a cultural visit.

This was a strong program for several reasons. First, students had a structured, challenging classroom experience. This classroom experience was then augmented with out-of-classroom visits to see the "real world." Perhaps the greatest strength of the program was that it was designed around global issues critical to engineering and technology. The students were able to learn about these issues and experience them first hand. The mentored travel paradigm scales relatively well—we were able to provide this experience for 17 students and could accommodate about 25 at a time in the future.

The initial offering of this mentored travel program required a lot of effort on the part of the faculty director. He not only arranged the travel (with a lot of help from the International Study Office) but developed the course curriculum. The college paid for his spouse and children to accompany him. We believe we have enough potential directors such that they can rotate every three years. Nevertheless, the demand of this program on faculty is an issue of concern.

France

The France program was an extension program done in partnership with Georgia Institute of Technology, which operates a permanent facility in Lorraine, France. During the summer program, GT-France offers about 25 courses, including a variety of sophomore and junior level engineering courses as well as courses in the French language. Most courses are taught by GT faculty in English. Currently GT-France can accommodate 150 students, although this is being expanded in the future. Seven BYU students participated in the summer program. Fridays and weekends were left free; students were encouraged to travel during this time. In addition, BYU arranged for several company visits, including an outstanding visit to Airbus. Fig. 4 shows the students in this program.

Fig. 4. Students at GT-France.

The advantages of this program include, 1) students were able to take engineering courses that fulfilled major requirements, 2) students were exposed to European culture through self-directed tours taken on the weekends, and 3) students visited several international companies. The program scales easily. BYU benefited greatly from the infrastructure Georgia Tech already has in place, both in terms of the physical facilities and the classes.

Although students had an enriching experience touring Europe (while taking required engineering courses), their exposure to and understanding of globalization issues, one of our main objectives for this type of study abroad program, were weak. This was strikingly evident in the fact that students were not enthusiastic about the company visits, as they interrupted their touring. We did not do a good job preparing these students beforehand and this showed in their lack of understanding regarding learning versus "seeing the sights."

We decided in 2008 to augment this program with a program of our own in Europe. This new program is being patterned after the successful China program. We think a more structured program and a greater emphasis on the academic purpose for being in Europe will result in better achievement of objectives.

Romania

The program in Romania was an extended field trip format. Students were invited to Romania to make presentations to Romanian engineering students on engineering ethics. While there, they also toured major construction sites. Seven students participated. We are unsure of the long term outlook for this program; however, a similar invitation has been extended for a student group this coming year in Egypt and Jordan. Figs. 5 and 6 show students in this program.

Fig. 5. Students making a presentation to colleagues in Romania on engineering ethics

Fig. 6. Touring a construction site in Europe.

Mexico

This program is a service learning program tightly coupled to a Civil Engineering course on hydrologic modeling. At the beginning of the semester professors at BYU and partner universities in Mexico met to select a number of real water projects of interest that could be modeled using software developed at BYU. Possible projects involved analyzing and making recommendations regarding water runoff, ground infiltration, flood control, reservoir management and mitigation of adverse effects on water quality. Student teams were formed for each project at both places and these teams worked together via email and the Internet. Before traveling, the teams defined the problem, determined objectives, developed and completed tasks and performed preliminary modeling. Most of the communication was conducted in Spanish. Towards the end of the semester, BYU students traveled to Mexico for two weeks and met with their Mexican counterparts. They visited the actual sites, met with stakeholders, refined their models and made final recommendations. Project presentations were given in Spanish. Last year 17 students participated. Pictures of this program are given in Figs. 7 and 8.

This program has existed for several years. Previously the professor directing the program was inclined to discontinue it because, frankly, he wasn't sure it was valued. The emphasis of the college in support of these programs has reinvigorated the faculty director. We also have provided $10,000 in support for the past two years to help with the logistics.

This has been a strong program. Students not only gain cultural sensitivity, they learn about working in multi-national teams, gain problem solving skills (working on real projects) and learn sophisticated software well enough to help teach it to others. Students are exposed to the vocabulary of professional Spanish.[6] A number of students have considered this to be the most significant learning experience they have had at the university.

Fig. 7. BYU and Mexican student groups.

Fig. 8. A BYU and Mexican student team work together.

Tonga

This program was a service learning project associated with Engineers Without Borders,[7] a chapter of which was started at BYU this past year. For the inaugural project, students developed and implemented a small scale facility for the conversion of coconut oil to bio-diesel fuel on the Pacific island of Tonga.

To prepare for this project, students enrolled in a new course titled, "Global Projects in Engineering and Technology." The course was open to all disciplines and counted as a technical elective. As part of the course, students worked in multi-disciplinary teams on one of six elements of the project. Students focused on developing appropriate, sustainable technology. They built, tested, and refined the hardware for the project.[8]

At the end of the semester, twenty four students traveled to Tonga to set up a pilot bio-diesel facility. The trip was ultimately successful; however, the group did experience a number of difficulties. The main problem was that much of the supplies and hardware they had pre-shipped to the island had not arrived when they got there. Getting the supplies the last leg to Tonga in time for them to be used was itself a lesson in cultural differences. In the end students were able to demonstrate the bio-diesel process to local farmers as well as to government officials, and the trip was judged a success.

The strengths of this program were similar to the Mexico program. Students enjoyed using their engineering skills to help others. They learned about problem solving and gained leadership and team experience. Students also learned from the difficulties—they learned that sometimes the biggest obstacles to success are not technical in nature.

We learned that in the future a pre-trip is absolutely necessary. This has already taken place for the next project which will be in Peru. We also realized the advantages of partnering with a group that has long experience working in a country, has developed relationships with city officials, etc., and knows how to "get things done" in that particular country.

Fig. 9. Students in Tonga for Engineers Without Borders project.

Fig. 10. Students demonstrating bio-diesel process to selected government officials.

PACE

The last program discussed here is not technically a study abroad program, but it does have a strong international component and achieves many of the same outcomes. It is known as "PACE," which stands for Partners for Advancement of Collaborative Education, a consortium of companies (led by General Motors) and universities, which agree to work together to provide students with international collaborative CAD/CAM experiences. Acting as the lead university, BYU students coordinated the efforts of 20 student teams across the globe, including teams in China, India, Korea, Sweden, Germany, Brazil, Mexico and Australia, in designing and building a Formula 1 style racecar.[9] Subsystems were designed and built by student teams at their own universities; these systems were assembled at BYU into a working vehicle. In some instances BYU students traveled to other universities and trained students there in the use of software tools.

The project obviously had a very heavy design flavor to it. Students gained experience in design, teamwork, project management and leadership. Students learned how to communicate with other teams around the world using software tools as the lingua franca. They also learned of some of the challenges associated with building hardware in multiple locations and in working across multiple time zones.

Fig. 11. PACE team members coordinated work through video conferences.

Fig. 12. PACE members pose in front of the vehicle built as part of the PACE project.

These programs involved about 85 students total. To encourage participation, the college provided financial aid (at least $500) to all students who traveled.

Some Observations

What did we learn from these experiences? A few of the lessons include,

- With the exception of GT-France, which was essentially run by Georgia Tech, the programs' successes were largely attributable to the drive and enthusiasm of faculty. One of our greatest concerns is providing rewards and support for faculty so they continue to want to do this. In the future we may be constrained in our ability to expand study abroad opportunities by the number of faculty willing to be program directors. We have provided faculty who have started new programs with fellowships and other support. For longer programs, we encourage faculty to take spouse and family, if they desire.

  In the end, faculty members are driven by the reward system. Although directing a study abroad program cannot compensate for a fatal weakness in some other area of performance, it is viewed very positively in the college and has been a positive factor in rank advancements.

- The programs would not have happened without the strong support of the college leadership. College support has communicated to the faculty that we value these activities.

- In each case we did a program evaluation. We feel this has been helpful in making sure programs stay aligned with objectives and in learning how to do things better. However, we are still developing assessment metrics. We discuss this more in the next section.

- We learned the importance of good student preparation before study abroad begins. Some programs did this better than others, and it showed. For 2008, we are moving to having a common preparation seminar for all programs (with some breakout sections focused on particular areas or countries of the world). Ideally students should receive some exposure to four areas: 1) cultural issues, such as cultural diversity, ethnocentrism, communication across cultures, 2) country issues, such as a brief introduction to a country or region's history, economy and politics, 3) study abroad issues, such as handling money, safety and health, and 4) globalization issues, such as trade policy, outsourcing, intellectual property and technology. Two of the preparatory reading resources used at BYU have included, *Globalization, A Very Short Introduction*,[10] and *The Cultural Dimension of International Business*.[11]

- We focused on several specific study abroad formats: mentored travel, extended field trip, service learning and international design, partly because these programs scale well. This has allowed us to ramp up relatively quickly. Although not discussed, here we also sponsored several international internships.

- We received excellent support from the university International Study Programs office. Without their assistance, we could not have run seven programs. Nevertheless, we will not be able to expand much further without an in-house college director. We are working on this.

- These programs are synergistic with another college goal of increasing women enrolled in engineering and technology. About 25% of the participants were women (which is, sad to say, double the percentage of women in the college).

- As the college leadership, we are impressed with the potential of humanitarian projects to provide both excellent learning opportunities for our students and to contribute to improving the living conditions of mankind.

Towards the Definition of Program Principles and Assessment of Outcomes

As we have expanded our study abroad activities we have felt to revisit several times both principles of operation and the desired set of outcomes. In Table 2 below we give the current draft of the document explaining these:

Table 2

DRAFT, 4 January 2008
Fulton College of Engineering and Technology

International Educational Experiences

Operating Principles and Desired Outcomes

One of the strategic goals of the College is to provide a substantial number of our students with a significant international, technical experience. The objective of this experience is to improve the ability of our students to thrive in an increasingly international technical environment. As international experiences are often resource-intensive and involve significant liability, they must be carefully managed. This document articulates the principles that should be followed as these international experiences are designed and implemented, and provides guidelines for educational outcomes.

Program Principles

1. International programs are academic in nature with the overarching goal of student learning. It must be clear to students that the primary goals of the experience will be academic, and that their participation should be directed toward that goal.
2. All international experiences are associated with appropriate credit. A significant portion of the credit meets requirements for the students' major.
3. Coursework associated with international experiences is of the highest quality. Students should expect a detailed syllabus, appropriate workloads, meaningful assignments and evaluation.
4. Appropriate educational outcomes are associated with each program, and achievement of these outcomes is carefully assessed.
5. Students are prepared *before* any travel via readings, seminars, etc.
6. Programs, faculty and students all meet the standards established by the International Study Programs office.
7. All participants in any international experience realize that they are ambassadors of BYU and the College and as such behave professionally at all times.

8. All international travel must be approved by appropriate university officers, and meet all university standards.
9. Student costs for all programs must be commensurate with the value of the experience and amount of credit.
10. Any required travel should not interfere significantly with other classes.

Program Models

There are a number of possible program models that can meet the objectives for international experiences. For the purposes of this document the college has defined four models:

1. *Mentored Travel Programs*: These are traditional study abroad programs where students spend a term or semester at a foreign location with BYU faculty directors, taking classes and participating in other appropriate activities.
2. *Service Learning Programs*: Service-oriented programs are designed such that the outcomes of the course benefit a needy community in a foreign venue. All such programs must meet the learning outcomes specified for international experiences. Any of the three models described above can be used to carry out these types of programs.
3. *International Design/Capstone Projects*: International experiences may be integrated with departmental senior design/capstone programs. In this model groups of students are assigned projects that have international content.
4. *Supervised Internships*: In these programs students work in carefully-selected international organizations under the supervision of a faculty member.

Learning Outcomes

Learning outcomes for international experiences should be carefully defined and assessed. In addition to the outcomes given below, departments may have additional outcomes associated with a specific course.

Outcomes: Study Abroad Programs

1. Students understand key globalization issues that influence their disciplines.
2. Students learn about other cultures, languages and communication across cultures,
3. Students understand a country's or region's context, such as its history, economics, political system, etc.
4. Students understand the opportunities associated with working overseas.
5. Students further their education and make progress towards graduation.

Outcomes: Service Learning Programs

1. Students learn and practice a multi-disciplinary design process in the context of a technical humanitarian project.
2. Students apply principles of technology sustainability.
3. Students have an opportunity to practice leadership and teamwork.
4. Students learn about other cultures, languages and communication across cultures.
5. Students understand key globalization issues that influence their disciplines.

Outcomes: International Design/Capstone projects

1. Students execute a technical project in conjunction with abroad student teams, or under the direction of a company located abroad.
2. Students learn how to address issues associated with diverse design teams (different time zones, backgrounds, skill levels, software tools, etc.)
3. Students learn about the design process in the context of another culture. This could include challenges related to obtaining customer requirements, concept selection, prototype development, technology sustainability, manufacturing, etc.
4. Students have the opportunity to practice leadership and teamwork.

5. Students learn about other cultures, languages and communication across cultures.

Besides individual student evaluations, which were done for all programs, we provide a rough evaluation in Table 3 of each of these programs according to the above outcomes. The scale used was the following: 1=Weak, 3=Good, 5=Excellent. Assuming all the outcomes have equal weight, we can see that China and PACE were our two strongest programs, with France and Romania as our two weakest programs.

Table 3

Desired Outcome	China	France	Romania	Mexico	Tonga	PACE
Students understand key globalization issues	5	2	3	2	1	NA
Students learn about other cultures, languages, and communication across cultures	5	3	3	5	4	3
Students understand history, economics or politics	3	2	3	NA	NA	NA
Students understand the opportunities associated with working overseas	5	3	2	NA	NA	NA
Students further their education and make progress towards graduation	3	5	3	NA	NA	NA
Students learn and practice a multi-disciplinary design process	NA	NA	NA	4	5	5
Students apply principles of technology sustainability	NA	NA	NA	4	5	NA
Students practice leadership and teamwork	NA	NA	NA	4	4	4
Students learn how to address issues associated with diverse design teams	NA	NA	NA	4	NA	5
Students learn about the design process in the context of another culture	NA	NA	NA	NA	NA	4
Average	4.2	3.0	2.8	3.8	3.8	4.2

Definition of outcomes and assessment of outcomes is an on-going process. We continue to work on developing and assessing specific outcomes for each type of program.

The Emergence of Humanitarian Projects

We have been impressed and perhaps a little bit surprised regarding how we have come to feel about humanitarian projects. Previously we viewed study abroad as a way to learn what developed countries were doing and how to prepare our students to remain competitive in the global marketplace. However, we have come to understand that another motivation for promoting international technical experience relates to the range and scale of technological needs of mankind in the 21st century. Some of the most challenging technical problems facing the

world include providing the basic needs of clean water, sanitation, infrastructure, energy, health care and transportation to the majority of the world's population which lives in developing countries on meager resources.

These are challenging technical problems in their own right, but often come with the further constraints of requiring low cost solutions which incorporate sustainable technology that is appropriate to the local circumstances. These problems teach leadership and teamwork, multi-disciplinary problem solving, and the very process of defining solutions involves learning cultural sensitivity.

On top of these advantages, students find these projects to be very worthwhile and fulfilling. As stated by Krishna S. Athreya, head of Engineers for a Sustainable World, "helping the impoverished have a better life can, for students, be a life-changing experience."[12]

We will continue to support these types of programs and consider them to be just as valuable—perhaps more so—than traditional study abroad programs.

Summary

In this paper we have described our efforts in developing study abroad programs over the past two years. We began by studying exemplary programs of others. For the 2006/2007 school year, we sponsored seven programs of various format types. We discussed the strengths and weaknesses of these programs, what we learned, and what we intend to do differently next time.

We focused on four particular formats that best meet our objectives and resources. Other institutions are likely to choose a different mix of formats to meet their needs. The formats we chose scale relatively well, yet providing experiences for an increasing number of interested students remains a challenge.

Defining program principles and assessing learning outcomes is an on-going process. Learning outcomes have been revised several times as we gain experience and deepen our understanding of what study abroad programs can do for students. We look forward to continuing our efforts at refinement and assessment.

We are convinced these programs can offer students very powerful learning experiences.

References

[1] T. Friedman, *The World is Flat*, Farrar, Straus and Giroux, 2005

[2] http://seattlepi.nwsource.com/boeing/787/787primer.asp

[3] P. D. Galloway, *The 21st Century Engineer, A Proposal for Engineering Reform,* ASCE Press, 2008.

[4] A. Parkinson, "Engineering Study Abroad Programs: Formats, Challenges, Best Practices, *Proceedings ASEE Annual Conference*, Paper AC 2007-422, Honolulu, HI, 2007

[5] J. Harb, R. Rowley, S. Magleby, A. Parkinson, "Going Global: Implementation of a College-wide Initiative to Prepare Engineering and Technology Students for the 21st Century," *Proceedings ASEE Annual Conf.*, Paper AC 2007-2912, Honolulu, HI, 2007.

[6] More than 75% of students in the college of engineering and technology speak a second language. This is a result of serving as missionaries in many different countries around the world. However, although they have good conversational skills, their experience speaking in a professional environment has been limited.
[7] http://www.ewb-usa.org/
[8] A. Frankman, J. Jones, W. Vincent Wilding, R. Lewis, "Training Internationally Responsible Engineers," *Proceedings ASEE Annual Conference*, Paper AC2007-301, Honolulu, HI 2007
[9] M. Webster, D. Korth, O. Carlson, C. G. Jensen, 'PACE Global Vehicle Collaboration," *Proceedings ASEE Annual Conference*, Paper AC2007-1817, Honolulu, HI 2007
[10] M. B. Steger, *Globalization, A Very Short Introduction*, Oxford University Press, 2003
[11] G. P. Ferraro, *The Cultural Dimension of International Business, Fifth Edition*, Pearson, Prentice Hall, 2006.
[12] T. K. Grose, "A World-Class Act", *ASEE Prism,* Sep. 2004.