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Cover Page Footnote

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Engineering Study Abroad Programs: Formats, Challenges, Best Practices

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ABSTRACT
This paper is a report of a survey of engineering study abroad programs made in order to understand a number of questions, such as: 1) what types of programs are in existence, 2) what are the challenges associated with these programs, and 3) what constitutes a set of best practices regarding these programs?

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Introduction

Engineering is a global enterprise. Is it not uncommon for engineers to work on multi-national teams designing products which will be manufactured in one part of the world (e.g. Asia) to be sold in another part of the world (e.g. Europe and North America). As chronicled in Thomas Friedman's bestselling book, *The World is Flat* [1], the advances made by engineers have made it possible for their work to be done nearly anywhere. Engineers, therefore, need to have a broad understanding of other cultures and countries.

To further emphasize this point, consider the following three quotes from, respectively, William Wulf, president of National Academy of Engineering; Duane Abata, president of ASEE, and Ken Kohrs, former vice president of Ford Motor Company:

> *...engineering is now practiced in a global, holistic business context, and engineers must design under constraints that reflect that context. In the future, understanding other cultures, speaking other languages, and communicating with people from marketing and finance will be just as fundamental to the practice of engineering as physics and calculus.* [2]

> *Outsourcing is affecting engineering and all the facets that encompass engineering, including research, design, marketing and service...This is a major revolution in engineering education. We must internationalize our curriculum, to include not only the study of mathematics and the sciences but intercultural interaction as well. We must mold our students to be entrepreneurs, and spirited international adventurers as well.* [3]

> *What's the relevance of globalization to you personally, and to your future in engineering? I can answer that in one word: Everything. No matter what area of engineering you enter, your ability to remain on the leading edge, and to progress in our organization, will depend largely on your capacity to connect and communicate globally.* [4]

The above quotes emphasize the importance of understanding the impact of globalization upon traditional engineering activities. However, as mentioned by one of the reviewers of this paper, 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, health care and transportation to the majority of the world's population which lives in developing countries on meager resources.

Given these reasons, it is to be expected that more and more engineering programs are sponsoring study abroad programs. Participation is increasing but is still relatively modest. The most recent data indicate that in 2003/04 school year, 5,548 engineering

students participated in some form of study abroad program [5]. This would represent about 7.5% of the graduating class, based on the most recent ASEE graduation data [6]. Accordingly, a number of universities have set ambitious goals to increase the number of engineering students with an international experience. As an example, Georgia Tech has set a goal of having half the student body participate in an international experience by 2011 [7]. Purdue has a goal of 20% of the engineering student body. Virginia Tech has a goal of 15% by 2011 [8].

The purpose of this paper is to examine engineering study abroad programs in an effort to understand answers to several questions, including 1) what kinds of programs are currently in existence, 2) what are the challenges associated with these programs, and 3) what constitutes a set of best practices regarding these programs? These questions are examined from an administrator's viewpoint—from the viewpoint of someone who would like to implement such programs in his own college. Thus the issues examined extend beyond the student experience to include things such as cost, required infrastructure, need for faculty, etc.

In order to answer these questions, approximately 25 programs were reviewed. These included programs mentioned in the literature, programs mentioned in interviews with program directors, programs described on the web, and programs which were represented at the 9th Annual Colloquium on International Engineering Education [9]. The survey was intended to be representative in character rather than comprehensive in scope. No attempt was made to contact, for example, all the schools which have ABET accreditation. Many of the programs reviewed here were mentioned in the literature or by others as having exemplary programs and also represented a wide spectrum of program types.

Program Formats

As programs were reviewed, various types of programs were observed. For the discussion which follows, it will be useful in this section to categorize programs and briefly discuss some of their attributes. These categorizations are not all inclusive; some programs cut across more than one category. The formats observed include:

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. Students receive an in-depth experience associated with learning a language and living and studying abroad. This type of program often requires substantial initiative on the part of the student.

Extended Field Trip
This format involves a 1-3 week tour involving visits to numerous countries, companies, and/or universities. The idea is to obtain a "snapshot" of the world via a broad exposure to numerous places. Obviously the exposure is brief. This type of program is good at communicating the state of the world and what the issues are associated with global engineering and manufacturing. It does not provide much depth in how to address these issues. It can be a good program to motivate students to be involved in more extensive programs.

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. These programs can serve as a good platform from which students can explore the abroad country. These programs usually scale more easily than some of the other formats but do not provide an in-depth exposure to the culture.

Internship or Co-op
Students work abroad at a foreign company or at an international branch of a U.S. company. This type of experience can be quite different from other study abroad formats. An internship is often less structured than coursework yet can include a lot of informal learning, particularly regarding business issues involving teamwork, communication, design, manufacturing, etc. Internships are labor-intensive to arrange.

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. This type of program may provide a more comfortable format for some students but less immersion in the culture.

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. Worcester Polytechnic Institute (WPI) is perhaps the leader in this type of format. There has also been growing interest in programs such as Engineers Without Borders, which provide service learning via humanitarian projects.

Research Abroad
A number of universities, such as Massachusetts Institute of Technology (MIT), provide international experiences for students which involve research. Such programs typically involve placing one or two students at a time. The student travels to an abroad laboratory and conducts research under the guidance of a faculty member or post doc, etc.

Exemplary Programs

A number of exemplary programs were studied as part of the survey. Shuman et al. provide an overview of some of these programs [10]. The University of Rhode Island has also compiled a list of programs as part of the 9th Annual Colloquium on International Engineering Education [11]. Several of these will be reviewed in this section.

Of the programs studied, WPI appears to send the largest fraction of students abroad each year. Each year more than half the junior class (>300 students) have a study abroad experience [12]. WPI's program is somewhat unique in that it is project-based. These projects are referred to as IQP's (Interactive Qualifying Project) and MQP's (Major Qualifying Project). An IQP deals with the relationship between technology and society. An MQP requires students to synthesize previous study to solve problems or perform tasks in the major field. The IQP and MQP are central features of the WPI Plan, an approach to engineering undergraduate education which "emphasizes project-based learning, student choice in development of educational experiences, and verification that students are competent as professionals." These projects involve a team of 3-4 students and last about two months. A group of approximately 24 students travels with two faculty to a project center. There are more than 20 project centers on five continents, including Hungary, Ireland, France, Thailand, Denmark, Hong Kong, England, Australia, Germany, Mexico and Canada [13]. Projects have included cataloging endangered public art in Venice, developing solar energy in Thailand, and developing effective fertilizer application techniques in Costa Rica [14].

Iowa State also runs a relatively large program [15], with 170 engineering college participants in 2005 [16]. Several elements of their programs are worth noting. First, the college has five summer programs for students, examples of which include taking material science courses in London, doing a design project in Germany, and studying Chemical Engineering in Spain. The college also has approximately 30 exchange agreements with universities around the world. Although some of these agreements are university-wide, the majority have been negotiated directly by the engineering college. The preference of the college is to not only have agreements in place with strong abroad universities, but to complement these with domestic and international partners to form a tri-lateral relationship. One example is the relationship between Iowa State, Hochschule Mannheim and John Deere. Both American and German students complete internships at local and abroad John Deere locations. This gives students the opportunity to experience John Deere at both an American and German facility [17]. These types of programs are complicated to set up and relatively expensive to run, in terms of the resources required from the industrial partner. Thus they are limited to just a few (2-3) students per location per year. Iowa State's program includes an International Task Team, composed of faculty representatives from each of the departments, and a large student organization (600+) called the Society of International Engineers.

Iowa State also offers a Languages and Cultures for Professions program. Students complete a second major in French, German, Russian Studies, Spanish or Chinese (minor) by completing 30 credits of course work beyond the second-year level. An internship (such as those described above) is also required [18].

MIT runs the MISTI program (MIT International Science and Technology Initiative), with locations in France, Germany, India, Italy, Japan, and Singapore. Since 1983, more than 1400 students have been placed

in internships in laboratories and offices with partner companies [19].

Pittsburgh has run a very unique program called "Semester at Sea" [20]. Students live aboard a cruise ship (the engineering contingent is a small part of the whole group) and make visits to companies and cultural sites during ports of call. While at sea the students take courses. In the 2004 year, the itinerary was the Pacific Rim and included stops in Alaska, Russia, Korea, China, Hong Kong, Vietnam, Taiwan, and Japan. Students took courses in global manufacturing systems that focused on the global supply chain. Thirty one engineering students from 18 institutions participated. Visits to manufacturing companies complemented the on-board curriculum. The Semester at Sea program has recently moved to the University of Virginia [21].

Georgia Tech [22] and Michigan [23] both run programs at Shanghai Jiao Tong University in China. The models are similar: they use facilities at the university and teach courses with their own faculty in English. Georgia Tech has had its own facility in France since 1990. It offers a relatively large summer program to 150 undergraduates each year, with 25 courses taught in English. This will be expanded to 250 students in 2008. They also have a dual degree M.S. program whereby a student obtains a M.S. from Georgia Tech as well as from a partner French university in about 18 months [24].

Georgia Tech recently announced its "International Plan." Students from any discipline spend two terms abroad and take courses in international relations and cultural issues. They also complete a capstone course in which their international skills are used [25]. Michigan has a similar program in Global Engineering that involves completing 24 credit hours of course work along with a study abroad experience [26]. A number of other universities offer some sort of global or international certificate to engineering students, such as Mississippi State, North Carolina State, Penn State and Purdue [11].

The University of Cincinnati combines a unique international co-op program with intensive language study [27, 28]. During the five year undergraduate program, students have six quarters of co-op experience spread over their sophomore, junior and senior years. Students take culture and language courses to prepare them for a six month international co-op experience. The first language course replaces six weeks of the co-op experience and is intensive: students study for six hours a day five days a week. Over the next two quarters students take additional courses which improve language skills and expose them to history, culture and politics.

One of the most comprehensive programs surveyed, in terms of integrated activities, is the Global Engineering Alliance for Research and Education (GEARE) program at Purdue [29]. It is one of the first programs to integrate international study with internships and a multi-national design team project. The program involves partner universities in India, China, Germany and Mexico. The program is an exchange program. Students apply while freshmen. They are admitted through a relatively extensive screening process which includes criteria such as academic qualifications, language skills, leadership skills, ability to represent Purdue well, etc. [30]. During the sophomore year, students study German or Chinese. It is not expected that they will become proficient enough to take engineering courses in these languages; rather the goal is for students to be able to travel, shop, etc. or perhaps present a project report in the second language. In the summer between the sophomore and junior years, students do a domestic internship for a partner company which also operates abroad. Partner companies include Siemens, Ford, John Deere, Cummins Engine, GM and United Technologies. At the start of the second semester of the junior year, students travel abroad. Typically, for the first three months they complete a three month internship at the abroad office of the partner company. Then they complete one semester of courses in the abroad country, which are taught in English. (In China, students do a six week internship at the beginning and end of the semester, because of the timing of semesters). Students begin a design project with team members from the abroad university and develop a conceptual design. At the beginning of the senior year, the entire design team moves to Purdue where they focus on prototype selection and fabrication.

The Global Engineering Education Exchange (Global E^3) is an international consortium of universities who agree to exchange students [31]. It contains about 37 U.S. universities and 50 non- U.S. universities. Participating students receive credit at their home university for courses taken abroad. Last year about 200 students from the U.S. participated. The consortium is run by the Institute of International Education.

The University of Rhode Island is well known for its International Engineering Program (IEP) [32, 33]. At the undergraduate level, students study a language simultaneously with engineering and earn two degrees—a B.A. in the language and a B.S. in their field of engineering. In the fourth year of the five year program, students study abroad for a semester at one of approximately ten partner universities and then complete a six month internship with an abroad company. Approximately 20% of the undergraduate engineering students are now participating--about 35 students are sent abroad each year. A dual degree M.S. program is also offered. For this program, students spend one year at each university. A dual degree Ph.D. program is being developed.

Virginia Tech also runs a dual degree program at both the B.S. and M.S. levels [34]. For the German program, students spend a year at the German university after taking six semesters in German. At graduation, they receive degrees from the German university and Virginia Tech.

A summary of the programs surveyed is shown in Table 1.

Table 1
Engineering Study Abroad Programs

University/ Program	Location	Duration	Type	Description/ Structure	Number (U.S. students per year)	Lang.	Ref
University of Arizona	Exchange agreements with 15 countries	Varies	Exchange				[11]
	Germany	Summer 6 weeks	Partner Subcontract with University of Stuttgart	Students take 10 credits (German, Engineering, and General Education)	New	English	[35]
Boston University	Germany, Mexico, Israel	Spring	Partner Subcontract	Students take five courses in English from abroad university faculty. (language, sociology, and three technical). Courses are official BU courses.		English	[36]
Brown	India	Summer	Internships	Typically at U.S. subsidiary abroad	12 -25	English	
	Netherlands	1-2 weeks	Extended Field Trip	Visit companies	10-15	English	
Brigham Young	China	Spring	Mentored travel	Students study Chinese culture and language, visit companies	16	English	[37]
	Mexico, Various	2 weeks	Service Learning	Engineers without Borders	30	Spanish English	
Cal Poly	Germany, Australia, Sweden, Taiwan, Finland	Six months	Exchange program	Take courses at abroad university	15	English	[38]

University/ Program	Location	Duration	Type	Description/ Structure	Number (U.S. students per year)	Lang.	Ref
Cincinnati	Japan, Germany Latin America	10 weeks	Internship	Intensive language and culture courses before leaving; work abroad		Japanese, German, Spanish	[27] [28]
Connecticut, EUROTECH	Germany	Spr/Sum junior yr local internship with German company, Senior year 1 sem. abroad and/or 6 mo. internship in Germany	Five year program, BA in German, BS in Engineering	Junior year work with German company at home; senior year one semester study abroad and six month work experience	12	German	[39]
University of Dayton Engineers in Technical, Humanitarian Opportunities of Service-learning (ETHOS)	Latin America Africa	Summer	Service Learning	Service internships or projects which support development of technology in developing world		Spanish, English	[40]
	Italy, China, Ecuador	Summer	Mentored Learning	Engineering and general education courses			
	China, Germany, France	Various	Partnerships for research and exchange				
Duke Engineering World Health	Nicaragua, El Salvador, Honduras, Tanzania	Summer	Service Learning	Repair and installation of medical equipment		English	[41]
Georgia Tech Professional Practice Work Abroad	France	Undergrad: Summer Grad: dual MS: 3 or 4 semesters	Extension Grad: Dual MS program	Regular GT courses taught by GT faculty. Program in ME, ECE and CS	175 ugrad 12 grad	Undergrad: English Grad: English and French	[24]
	Shanghai Jiao Tong University	Undergrad: Summer	Extension program	Regular GT courses taught by GT faculty.	50 ugrad	English	[22]
	Various	Semester	Internships				
Global Engineering Education Exchange (GE3) Approx. 37 U.S. Universities, 50 non-U.S. universities	Programs in 20 countries	GE3 programs are typically Winter term or a full academic year.	Exchange program	Courses in engineering at abroad university; opportunity for internship as well.	200	Some programs in English, others in abroad language	[31]

University/ Program	Location	Duration	Type	Description/ Structure	Number (U.S. students per year)	Lang.	Ref
Iowa State Global Academic Industrial Network(GAIN), Languages for Cultures and Professions, Engineering International programs	Relationships with 25 universities in 15 countries	Semester, year long and summer options	Exchange program. After foreign and domestic internship, students spend semester or year abroad.	Tri-lateral relationship: Iowa State, international education partner, global industrial partner	170	Some programs in English, some in abroad language	[17] [18]
MIT (MISTI) MIT International Science and Technology Initiatives	China, France, Germany, India, Italy, Japan, Mexico, Singapore	Varies	Internships, Research Abroad, some Study Abroad	Students placed at partner companies and universities. Before departure students are trained in language and culture	200		[19]
Michigan (IPE) International Programs in Engineering	Australia, China, France, Germany, Japan, Mexico, Turkey	Summer	Extension and Study Abroad	Engineering credit for most programs, also language, social science and humanities credit	70	In the case of China, UM courses in English by UM faculty	[23]
Milwaukee (MSOE)	Lubeck Univ. of Applied Sciences, (Germany)	9 months (Sep thru June) of junior year	Exchange program. Dual degree: BS from MSOE and Diplom-Ingenieur degree from Lubeck	Junior year courses for EE, ME or Intl Business. Attend with German students. Plus courses in German culture and language. All courses transfer directly.		English	[42]
Mississippi State	England	Summer (6 weeks)	Partner Subcontract	Students take two courses at University of Bristol; live with host families	10	English	[43] [44]
	Europe	2 weeks	Extended Field Trip	Visits to universities and companies in Europe	20	English	
Nebraska	Brazil, France, Italy, China	3-4 weeks	Mentored travel	Credit in Global Engineering along with general engineering course (e.g. Statics, Intro. To FEA) Courses are U. Neb courses taught by U. Neb faculty	10 (France) 12 (Brazil)	English	[45]
Pittsburgh, Plus3	Brazil, China, Chile, Germany, India	2 weeks	Integrated Field Trip Abroad	Involves students from business and engineering	30	English	[46]

University/ Program	Location	Duration	Type	Description/ Structure	Number (U.S. students per year)	Lang.	Ref
Purdue GEARE (Global Engineering Alliance for Research and Education)	Universität Karlsruhe (Germany), Shanghai Jiao Tong University Indian Institute of Technology Bombay	Time abroad Spring /Sum of junior year	Exchange program which includes internship	Domestic internship, foreign internship, one semester abroad, two semester design project, 18 months total.	12-15	Courses in English; project could be in host language.	[29] [30]
Rhode Island International Engineering Program	Germany, France, Spain, China (soon)	One year	Dual degree five year undergrad program. Dual degree two year MS program	For undergrad program: students study both language and engineering. During fourth year of five year program, they complete internship and study abroad at partner university	35	German, French, Spanish, or Chinese	[32]
Stanford	Centers in Australia, Beijing, Berlin, Florence, Kyoto,		Extension and exchange available	Take courses offered by Stanford faculty Beginning exchange program with China			
Syracuse	Spain, France	Summer	Research project or Internship. Large center in Madrid.	Credit for project or internship. Language classes may also be taken. Students live with host families.	5 for Madrid, Strasbourg 15 for London	English French	[47]
Virginia Tech	Germany, Sweden	1 year abroad senior program Dual BS 1 year abroad Dual MS	Two programs: Bi-lateral senior year abroad (Dual BS) program; Dual MS program	One year spent in Germany taking technical courses (BS program) VT students prepare by taking six semesters of German. MS degree: 1 year spent in Germany, 1 year at home	10	German, Swedish	[34]
Worcester Polytechnic Institute Global Perspective Program	Current projects in Hungary, Ireland, France, Thailand, Denmark, Hong Kong, England, Australia, Costa Rica, Italy, Namibia Exchange programs with Germany, Mexico, Sweden, Switzerland	8 weeks	Project-based study at extensions of WPI program	Project-based learning Student group (approx. 24) supervised by two WPI faculty. Students work in teams of 3-4. Project explores interrelationship between technology and society on topic chosen by sponsoring agency in host country. Exchange programs also	300	English	[12] [13] [14]

Challenges

In this section some of the challenges associated with these programs will be discussed. The decision regarding what challenges to include was somewhat arbitrary—focus has been kept on challenges that would perhaps be less obvious, even though obvious challenges are not any easier to solve. For example, the fact most U.S. students are not bilingual is perhaps obvious, but still provides a large obstacle in terms of students studying abroad.

How some institutions successfully address the challenges listed here is discussed in the Best Practices section of the paper. The challenges discussed here do not address the actual mechanics of setting up an exchange, or other form of study abroad program, which could be a paper in itself. Rather these are challenges associated with running nearly any type of program. Challenges include:

Scaling

Scaling refers to how easy or difficult it is to increase the number of participants. Some formats scale more easily than others. As can be seen in Table 1, many programs involve a small number of students. In particular, exchange programs typically do not scale easily—they usually reach a practical limit at 5-6 students per university. This is governed partly by the need to maintain parity of students with the exchange institution. In contrast, extension programs involving groups of students scale more easily. Georgia Tech, for example, can accommodate 150 students at its summer program in France and is planning an expansion of this program.

Recruiting Students

The rate at which engineering students elect to participate in study abroad is growing, but is still small. Although the attitude of students appears to be changing, students do not always perceive the importance of a study abroad experience. Students note a number of obstacles to participating in these types of programs. These include:

Time to Graduation. Engineering programs are already demanding and long. Students are reluctant to study abroad if this will delay graduation.

Expense. Study abroad programs are often (but not always) more expensive than going to school at the home university. This is one of the easier challenges to fix via scholarships.

Leaving Community of Family and Friends. A significant factor, depending on the type of program, is leaving comfortable surroundings of family and friends for the unknown. Study abroad participants need to be somewhat adventurous.

Difficulty Transferring Credits Back. Students sometimes find it difficult to transfer abroad credits back to the home university. This issue is complicated by the fact abroad universities are not accredited by ABET.

Timing of semesters. Abroad universities often operate on a different semester schedule.

Length of internships. Internships in some countries are typically no shorter than six months. This means a foreign internship could cut across two home semesters.

Recruiting Parents

Parents are often involved in the student's decision to study abroad. In some cases parents want their child to participate but the student does not share their enthusiasm; the reverse is also true—the student wants to participate but the parent is reluctant. In the latter case the concern is often with safety or health issues.

Recruiting Faculty

Some programs are limited by the number of faculty who are interested in participating. Faculty perceive these programs to be a lot of work. Time spent on these programs usually does not align with their research. Accordingly, participation in these programs may not count for much in rank advancement or tenure evaluation. Faculty must also be trained to handle a variety of situations ranging from crisis management (safety issues, natural disasters) to student health and disciplinary problems.

Assessment

Engineering programs are expected to conduct assessment to see if outcomes are being met. Study abroad programs involve a whole new set of variables and experiences which are difficult to assess. Recently, Lohmann et al. at Georgia Tech have described a research effort to measure the effectiveness of study abroad programs [48]. One of the tools they will be using to assess intercultural competence is the Intercultural Development Inventory [49]. Purdue University also has a program in place to assess global

competency, which includes quantitative and qualitative evaluation [50].

Cooperating with other departments
A number of exemplary programs involve close cooperation and adaptation of programs among various departments, such as among language programs and engineering programs. Flexibility on the part of all programs is often required to make dual major or other integrated programs work. This seems obvious, but people who have been down this road remark that faculty are not always willing to bend their program's requirements.

Best Practices

Based on the surveys conducted and conversations with many individuals involved in exemplary programs, the following are a set of best practices which have been observed:

Colleges need to have a suite of integrated programs
It is difficult to have one program meet the entire needs of a college. Most programs are limited at some point in scale—exchange programs typically do not get much larger than 6-8 per institution; extended field trips are practically limited to groups of no more than about 20; project-based experiences run from 5-20; an optimal size for tours is about 15. Further, universities will want programs that span the globe geographically. Thus most colleges will want to have a suite or spectrum of programs.

To accommodate significant fractions of engineering students, some of the programs in the suite should permit students to study in English while abroad. Although requiring students to achieve fluency in another language is laudable, such a requirement constitutes a high barrier to entry. Engineering programs are very demanding without such a requirement. Getting large numbers of students abroad, in a well designed program, is a worthy goal even if they do not become fluent in a second language. Further, getting them abroad may convince them of the advantages of learning a second language.

Some programs can be designed to feed into each other. For example, Pittsburgh's Plus3 program, which involves a two week extended field trip for freshman and sophomores, is being used to motivate students to have a longer experience when they become juniors or seniors.

Programs should have a clear set of desired outcomes
There may be a tendency in engineering study abroad programs to think, "if we get the students abroad, good things will happen, and that's enough" (and perhaps this is in large measure true). Or programs may have very general objectives such as, "students will understand better their place in the world." However valid these general objectives may be, specific objectives should be encouraged: What should students know about the history or culture of the abroad country? What should they know about such issues as communications or intellectual property? Specific objectives can help drive preparation beforehand and the planned experiences during the stay. They can also be a useful vehicle to promote student reflection during the experience.

As an example, below are given some objectives from a product design focused field trip program conducted at Brigham Young [51]:

Students will:

1) Understand issues associated with a global product development environment, including developing product needs in unfamiliar cultures, design for adaptability, managing distributed design teams and manufacturing at remote and/or distributed sites. Appreciate first-hand how successful global product development companies approach these issues.

2) Understand design strategies associated with concept selection, product architecture, economic modeling, prototyping and developing manufacturing systems for product development in a global environment.

3) Appreciate the challenges in managing product development issues across different countries, cultures and languages, and understand what tools and processes companies are using to address these challenges.

Having specific outcomes is prerequisite to the desirable goal of assessing if outcomes have been met. As mentioned earlier, Georgia Tech is beginning an effort in this regard [48].

Colleges should be proactive in recruiting students
Students are yet learning what it means, in terms of their careers, for the world to be flat. They still need to be convinced that a study abroad program is not just "nice," but a critical element of their education. To this

end, the best institutions 1) use students who have been abroad to recruit students, 2) use the advising process to recruit students and 3) use industrial advisory boards to recruit students. Recommendations 1 and 3 involve groups (other students, employers, successful alumni) which are highly credible with students. Recommendation 2 encourages a student to plan ahead. In one instance students indicated early advisement was one of the biggest single reasons they chose to do study abroad [16].

In a paper describing the program at the University of Rhode Island, the authors discuss their recruitment activities [33],

> *…since the concept of bilingual American engineers is still relatively new, it cannot be assumed that large numbers of students will enroll in the IEP (International Engineering Program) without active encouragement. The IEP, therefore, relies on an active advertising, promotion, and recruitment program. Mailings … go out to high school students, to teachers and to faculty. A high school outreach team, made up of current students and faculty, makes annual visits to high schools in the Rhode Island area. A regular newsletter, newspaper advertisements, journal advertisements, and even radio ads are a part of the regular cycle.*

As another example, at WPI, "We begin telling students about these opportunities at Admissions Open House events, followed up by sessions during New Student Orientation, residence hall meetings, and any other place we can get an audience. The single most successful effort we undertook back in 1997 that continues to this day is letting students talk to students. The Global Ambassadors—a volunteer group made up of anyone who went away the previous year—has been a valuable resource….Returned students love to tell their story and they are the ones who convince their peers that it is the best experience of their time at WPI" [52].

Colleges should reward faculty who are willing to do this

Faculty members who have been a chaperone for one of these programs know the experience is exhilarating but also a lot of hard work. The hours often extend from early in the morning to late at night. There can be constant travel, the strain of being responsible for a bunch of people, and the hassle of hotels, restaurants, buses, etc. Faculty who are willing to do this should be rewarded financially. They should be allowed and encouraged to take their families, if they so desire. They should also be recognized *and rewarded* during tenure and promotion process.

The college leadership needs to buy in with a long term commitment

A strong engineering abroad program, encompassing a suite of programs, requires a lot of effort. The needed momentum and resources cannot be achieved without the buy-in of the college leadership. To really be successful, a common vision of engineering study abroad needs to be shared by program staff, college leadership and college faculty. The University of Rhode Island, a highly recognized program, is in its 19th year. The stature reached by this program has grown gradually over the years. A long term commitment is needed.

Colleges should take an integrated approach coordinated by a centralized office

At some universities individual programs are scattered throughout the college and coordination only occurs on an ad hoc basis. The best programs have a centralized office that handles all programs in the college. This has several obvious advantages, such as providing "one-stop shopping" for students and providing for efficient handling of the myriad of similar details involved in study abroad programs. Besides gains in efficiency, however, such an office offers other significant benefits. First, the office can coordinate health and safety issues. As noted by Mello [12], these are serious concerns. Information regarding these issues cannot be allowed to "fall through the cracks." As programs expand, it becomes imperative that a central location exist to handle potential emergencies. Second, a centralized office can provide leverage and focus for other elements of study abroad such as student recruitment (through international fairs, etc.), activities of student chapters, and student preparation. Third, such an office can integrate activities so they complement each other. Shorter term programs can be used to recruit students into longer terms programs.

As an example of the scope of activities, at Purdue the Global Engineering Program Office oversees the Global Engineering Competency Certificate Program, short-term courses abroad, international design projects, global service learning projects, work/internships abroad, and a global opportunities fair [11].

Colleges should take advantage of any university infrastructure already in place

One of the first steps a college should take is to make a mapping of their own institution's support structures for study abroad so they leverage off of this as much as possible and do not replicate what already exists. It is not only infrastructure, but also contacts previously developed by the university that can greatly facilitate running a new program.

Each program needs to involve several faculty

It is not uncommon to find that a particular program has grown up based on the drive and enthusiasm of a particular faculty member. Such individuals are to be commended. However, as noted by Shuman et al. [10]. "Programs built around a single faculty member and his or her international connections are fragile and typically fail when that individual loses interest or moves." Having several faculty involved obviously spreads the workload around. More importantly, however, it allows for more faculty to own a program. This can be very important in achieving buy-in by a department or college. Iowa State has done this partially through its IMPACT program [17], whereby grants are made available for international travel for faculty, on condition that faculty from several departments go together and stay a few days. This has had the effect of creating broad-based support for programs in new areas.

Students are prepared before they go

The benefit of study abroad is significantly enhanced by prior preparation. Even if students do not have a deep understanding of issues surrounding globalization, communication across cultures, etc., but they are aware of what the issues are, they gain much more from the study abroad experience. The preparation might be something as minimal as a weekly seminar held the semester before students leave or involve taking several courses. 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 Brigham Young University (BYU) have included, *Globalization, A Very Short Introduction* [53], and *The Cultural Dimension of International Business* [54].

The BYU Experience of 2006/2007

Although BYU has a long history in running humanities-based study abroad programs, very little had previously been done inside the college of engineering and technology. At the college leadership level, we resolved to change this. After conducting the research presented in this paper, we decided to take the plunge and learn by experience. For the school year 2006/2007, we sponsored six different technical international programs. Each of these programs will be briefly mentioned.

The first program was a six week, mentored traveled program in China. After two faculty members visited a number of Chinese universities to better understand options, we decided to partner with Nanjing University (which does not have an engineering program). Nanjing, with whom BYU already had a relationship, is willing and able to provide lodging, classrooms and instructors for visiting students. Students took one class taught by Nanjing faculty, either in Business Chinese (for those students who already had some Mandarin proficiency) or Beginning Chinese, and a course entitled, "Globalization, Engineering and Technology," taught by the BYU professor who directed the program. Courses were augmented with visits to engineering companies and cultural sites in Shanghai, Beijing, Nanjing and Xi'An. We felt this was a strong program and will be running it again.

The second program was a service learning project associated with Engineers Without Borders, a chapter of which was started at BYU this past year. For the inaugural project, students developed appropriate technology for Tongan farmers to convert coconut oil in bio-diesel fuel. Twenty four students traveled to Tonga where they set up a pilot facility, taught farmers how to use it, and demonstrated the process for government officials. This was also a highly successful program, although it did have some glitches we hope to avoid in the future.

The third program was an extension program done in partnership with Georgia Tech, which (as previously mentioned) operates a permanent facility in Lorraine, France. Seven BYU students participated in the summer program, taking several engineering courses. Fridays and weekends were left free; students were encouraged to travel during this time. In addition, BYU arranged for several company visits. Although students had a tremendously 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 program, was weak. We would like to strengthen this element of this program.

The fourth program was mentored travel associated with a Civil Engineering course in water resources. As part of the course, 17 students traveled to Mexico for two weeks and worked with colleagues at a Mexican university to apply computer software to model five different water resource projects. This program has been running for several years. It has been very successful in terms of student learning and in terms of making friends for the university.

The fifth program involved a group of seven students and a faculty member who were invited to Romania to present lectures on engineering ethics. The students also toured construction sites. We are unsure of the long term outlook for this program.

The sixth program was associated with PACE, 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 coordinated the efforts of 20 student teams across the globe, including student teams in China, India, Korea, Sweden, Germany, Brazil, Mexico and Australia, in designing and building a Formula 1 style racecar. Subsystems were designed and built by student teams at their own universities; these systems were assembled at BYU into a working vehicle. This was not a study abroad program, but it did include a heavy international emphasis. This program was highly successful and will continue.

These programs involved about 90 students. To encourage participation, the college provided financial aid (at least $500) to all students who traveled.

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. Without this, they couldn't have happened. 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.
- 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.
- We learned the importance of good student preparation before study abroad begins. Some programs did this better than others, and it showed.
- We focused on a format of mentored travel experiences because, relative to other formats, these programs scale well. This has allowed us to ramp up relatively quickly.
- 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.
- We received excellent support from the university International Programs office. Without their assistance, we could not have run six programs. Nevertheless, we will not be able to expand much further without an in-house director. We are working on this.
- Donors are anxious to support these types of programs. We had not realized this.
- These programs are synergistic with another college goal of increasing women enrolled in engineering and technology. About 25% of the participants were women.

Summary

In this paper a number of issues regarding study abroad programs have been discussed, based on a survey of approximately 25 schools. At least nine different formats were observed. A number of exemplary programs were examined in detail. From these, numerous challenges as well as best practices to address these challenges were presented. Many of these practices were implemented by BYU during the 2006/2007 school year, when the college sponsored six different programs. As the globalization of engineering continues, the importance of study abroad will increase. In particular, U.S. students must be familiar with other countries and cultures if they are to remain competitive in the global engineering community.

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