AC 2009-1085: DESIGNING GLOBAL EXPERIENCES FOR ENGINEERING STUDENTS

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Designing Global Experiences for Engineering Students

Abstract

Participation in a foreign study program can teach students valuable skills outside their technical skill set. It has been recognized in academia and industry alike that engineers require an ever-broadening skill set in order to function competitively. Considering the increasingly globalized nature of the industry, an understanding of other cultures and strong cross-cultural communication skills will prove invaluable. Understandably, these skills are difficult to impart in a traditional engineering classroom. In order to address this challenge and offer students a global experience, a foreign study program has been developed for the bioengineering students at Arizona State University. The model was designed to be easily adaptable with three key components – minor modification of flow-charts, identification of host institutions, and active student encouragement. To avoid controversy regarding accreditation, the curriculum was modified to allow for travel abroad during either semester in the second or third years during which the student completes general engineering classes but would not have to take any major-specific courses (here, bioengineering). International host institutions that taught classes primarily in English and Spanish were identified with the rationale that these were the two languages most spoken by students at Arizona State University. Over twenty schools were found that offered the necessary classes, including the University College Dublin, the ITESM campuses in Mexico, and various technical institutes throughout the world. The final step is actively encouraging students to take advantage of the opportunity. This study provides a framework for the design and implementation of foreign study programs for engineering students with the testimonial support of the pilot students.

1. Introduction

Academia and industry have both acknowledged that engineering students require an increasingly broad set of skills, both technical and professional [1,3,5,6]. Within the professional skill set, strong communication skills are essential and should be emphasized as such within undergraduate curricula. As the engineering industry will only become more globalized, the ability to communicate cross-culturally will be a necessary aspect of this skill set [5,6,17,18]. Teaching these skills is challenging within the traditional classroom and it is proposed that the best way to impart these skills and provide a valuable learning experience is to design global experiences for engineering students. The idea of a global experience can be as simple as introducing a seminar series about different cultures and encouraging discussion between students that have spent time in other countries and students who have not. This would be especially effective in programs with diverse student bodies. Additionally, schools close to the United States/Mexico border have the unique advantage of being able to organize shorter trips to give their students a new perspective.

The focus of this paper is the design and implementation of a semester-long study abroad experience. Participation in a foreign study program can teach students valuable skills outside their technical skill set. If the program is done in a country with another language, language skills are acquired. Even in an English-speaking country, the student has to learn how to live in an environment most likely very different from home. The opportunity to travel and experience new cultures is one that should be encouraged and facilitated within the university.

2. Methods

In order to facilitate foreign study experiences, the first step was to examine the flowcharts for the bioengineering curriculum. Classes were then rearranged in order to allow for one semester in either the sophomore or junior year in which there were no bioengineering (BME-prefixed) courses. Once the flowcharts had been rearranged, an extensive search for international universities that offered these classes was performed. Universities were examined and selected based on the availability of technical classes and whether or not classes could be taken in English. The majority of the universities reported in this paper are either English- or Spanish-speaking. Additional schools could be investigated for students who speak other languages; however these schools are not presented here. The list of universities and corresponding contact information is provided in Appendix A.

3. Results

The flowcharts included in Appendix A offer alternative versions that allow for various "free" semesters for students at Arizona State University. While this is extremely program-specific, the idea here is that with a little effort, the curriculum flow can be tailored to fit a study-abroad program. A class key for the flowcharts listed is included, but the multiple examples are just to illustrate the point that not only can it be done, but it can be done multiple ways for multiple semesters.

It should be noted that students are still responsible for engineering courses during these semesters, just not any bioengineering (major-specific) courses. Also, these flowcharts are inclusive – it was assumed that the student entered college without any credit and will graduate without taking summer classes. The classes that were designated to stay in the semesters marked for foreign study were common engineering, science and math classes or general elective credit. This alleviates the concern that the content of major-specific classes differs from university to university.

The most extensively researched opportunity was an exchange at one of the various ITESM campuses. The Instituto Tecnologico y de Estudios Superiores de Monterrey (The Monterrey Institute of Technology and Higher Studies) has recently implemented a biomedical engineering degree program. Their classes have been acknowledged as "substantially equivalent" by ABET, making this an ideal starting point for an exchange program (http://www.abet.org/subequi.shtml). An extremely exciting recent development is the initiation of accreditation programs for international universities such as the ITESM [18]. As programs at these institutions become accredited, facilitating these types of exchanges will only get easier.

4. Discussion

In an increasingly globalized industry, an understanding of other cultures is becoming more important to engineers working in the field. Many universities, including Stanford and Purdue, have recognized this and have initiated foreign study programs for engineering students. The Purdue model is especially impressive: a group of their students spends the Spring semester abroad, followed by an internship at an international company or research lab. The following Fall semester, students from the host institution travel to the United States to study at Purdue [12]. This established exchange provides engineering students with the opportunity to experience living, working, and communicating in a foreign environment.

There are a variety of ways to approach a solution to this problem. In an effort to work toward the model that Purdue has, short trips might be the best way to begin. Two to four weeks would be a good start for a small group of bioengineering students to travel to another country and interact with students there. A good example of this type of trip is an initiative in the aerospace engineering department at Arizona State Univerisity – students from ASU collaborate with students from ITESM's Monterrey campus to complete their Senior Design projects. They communicate via teleconference and email throughout the year and then spend three weeks together to assemble and present their completed project. If relationships such as this could be initiated for the other disciplines, that would beneficial; the potential for positive cultural and intellectual exchange is great.

The flow charts presented in the appendix of this document are suggestions for students who want to complete their degree at Arizona State University in four years without summer school and who bring no transfer or AP credit in with them from high school. The schedule is, of course, more easily accomplished if advanced placement credit has been accumulated in high school – especially in math and science classes. Additionally, many students take summer classes; completing required classes outside the eight semesters shown in the flowcharts would also alleviate the stresses induced by the shifted schedule.

International Institutions

In most universities, if an engineering student wishes to study abroad, the burden of organization falls to them. Unfortunately for bioengineering students, if they were to search online for international universities with undergraduate bioengineering programs, they would have to be very persistent. Online databases of international study programs such as the IIE Passport site return no biomedical engineering programs for undergraduate students (http://www.iiepassport.org/). The universities listed in Appendix B could serve as a foundation for the pilot classes for these students. While the ITESM is by far the most viable option for a bioengineering exchange, the other universities listed also offer technical classes in a variety of engineering disciplines.

Again, an exciting advance is the initiation of ABET accreditation of international universities. A list of ABET accredited programs at international institutions is included in Table 6, additional unaccredited institutions with biomedical engineering programs are listed in Table 7. While there may be differences between the mission and aim of these programs, because of the limited number of schools with bio- or biomedical engineering tracks, these schools might be especially willing to start a relationship that would provide open lines of exchange, given the current relative lack of communication.

Obstacles

One of the challenges faced in encouraging foreign experiences is a language barrier. While the ideal situation is one in which the student goes to a country that speaks a language other than their native language, this is not always feasible. Many students have a second language – their family is bilingual or they have pursued classes – but many do not. Including a foreign study semester in the engineering curriculum is not meant to address the issue of learning a second language but rather to give the student a range of experiences that are important to their personal and professional maturation. That is to say that even without acquiring foreign language skills, this type of experience is still valuable.

Another sizable obstacle is the financial burden this places on many students. In order to overcome this, there are institutional grants available that promote study abroad. One extremely proactive approach to solving this problem is to provide a tuition waiver for 50 students each semester in order to get the program off the ground. It is expected that industry and alumni donors would be interested and willing to support this effort [13]. There are also myriad opportunities available to students through general scholarship applications.

Holding informational sessions where students who have had foreign study experiences share their stories with students who are interested would be valuable. This could be incorporated into any freshman seminar-type class – one of the sessions could focus on the globalization of the discipline and include a brief discussion of study abroad opportunities. It is important to involved students who have had the experience – having gone through the process as students, they understand the difficulties and rewards and can speak to them candidly.

Class Design

A note on the infrastructure suggested for a successful program: it would be beneficial to have a university contact that is also corresponding with the student. A good way to do this is to create an independent study course or a special topics course in which any student participating in a study abroad program would enroll. This would enhance the student's experience abroad. Assignments for this class would be centered on weekly journal entries. Expectations for these journal entries should be left open-ended to encourage student-directed writing, but there should also be a directed component every week. These assignments might include discussing a new word, phrase, or custom learned and recording the most uncomfortable moment or a success story for the week. A course description of an example class is provided in Appendix C. This is a suggested outline for a course in any university.

Student Testimonial

There is a relative dearth of examples of students who have successfully completed a semester of study abroad and still graduated on time; this is a testimonial from one student who did:

> "My semester abroad was excellent. I went through all the standard phases – infatuation, homesickness, rebound, and integration. I know how exciting it can be to live somewhere new, how frustrating and exhausting it can be to be far away from home in a culture you do not understand, and finally how interesting and rewarding the upward slope toward actually integrating into the new society can be. It was the reintegration when I got home that was actually the most difficult, then the paperwork associated with making all of my classes count and finally the stress of ensuring that I would, in fact, graduate on time. If this process can be smoothed out by the department taking a proactive attitude toward foreign study experiences, it would significantly facilitate student participation."

The understanding that global experiences are important is generally recognized in industry and academia; taking a proactive approach to providing these opportunities to undergraduate students will work toward refining curricula that truly prepare these students to succeed in their roles as professional engineers and active citizens.

5. Acknowledgements

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Appendix A: Curriculum Flowcharts

This appendix includes flowcharts for a four-year path to graduation with the current Bioengineering curriculum. Class Key included after Table 5.

Table 1: Current Suggested Flowchart

Fr: Fall	CHM 114*	ENG 101	MAT 265	BME 100	
Fr: Spring	BME 188**	ENG 102	MAT 266	PHY 121/122	
Soph: Fall	BME 200	CHM 231†	MAT 267	PHY 131/132	CSE 100
Soph: Spring	BME 235	EEE 202	MAT 275	MAE 212	HU/SB
Jnr: Fall	BME 318	IEE 380	MAT 343	CHM 341	BME 350
Jnr: Spring	BME 331	BME 370	BME 300	HU/SB	HU/SB
Snr: Fall	BME 413/23	BME 417	TE‡	HU/SB	
Snr: Spring	TE	BME 490	TE	HU/SB	

The following flowcharts are designed to have one semester where no BME prefixed courses will be taken. The suggested semester to study abroad is indicated in the Table title preceding each flowchart.

Table 2a-b: Fall Semester, Sophomore Year

CHM 114*	MAT 265	BME 100	PHY 121/122	
BME 188**	BME 200	MAT 266	ENG 105	PHY 131/132
CHM 231†	MAT 267	HU/SB	CSE 100	
BME 235	EEE 202	MAT 275	MAE 212	
BME 318	IEE 380	MAT 343	CHM 341	BME 350
BME 331	BME 370	BME 300	HU/SB	HU/SB
BME 413/23	BME 417	TE‡	HU/SB	
TE	BME 490	TE	HU/SB	

CHM 114*		MAT 265	BME 100	PHY 121/122
BME 188**	BME 200	MAT 266	ENG 105	PHY 131/132
Any EEE class	CSE 100	MAT 267	HU/SB	
BME 235	CHM 231†	MAT 275	MAE 212	
BME 318	IEE 380	MAT 343	CHM 341	BME 350
BME 331	BME 370	BME 300	HU/SB	HU/SB
BME 413/23	BME 417	TE‡	HU/SB	
TE	BME 490	TE	HU/SB	

*CHM 114 or 116; **BME 111/112 or BIO 188; †CHM 231/235 or 233/237; ‡BME 434, 418 or 419.

Table 3: Spring Semester Sophomore Year

CHM 114*	PHY 121/122	MAT 265	BME 100	
BME 188**	ENG 105	MAT 266	PHY 131/132	
BME 200	CHM 231†	MAT 267	BME 235	
	EEE 202	MAT 275	MAE 212	HU/SB
BME 318	IEE 380	MAT 343	CHM 341	BME 350
BME 331	BME 370	BME 300	HU/SB	HU/SB
BME 413/23	BME 417	TE‡	HU/SB	CSE 100
TE	BME 490	TE	HU/SB	

Tables 4a-c: Fall Semester Junior Year

CHM 114*	ENG 101	MAT 265	PHY 121/122	
BME 188**	ENG 102	MAT 266	PHY 131/132	BME 100
BME 200	CHM 231†	MAT 267	EEE 202	
BME 235	BME 318	MAT 275	BME 350	
MAE 212	IEE 380	MAT 343	CHM 341	CSE 100
BME 331	BME 370	BME 300	HU/SB	HU/SB
BME 413/23	BME 417	TE‡	HU/SB	HU/SB
TE	BME 490	TE	HU/SB	

CHM 114*	ENG 101	MAT 265	PHY 121/122	
BME 188**	ENG 102	MAT 266	PHY 131/132	BME 100
BME 200	CHM 231†	MAT 267	EEE 202	
BME 235	BME 318	MAT 275	BME 350	
MAE 212	HU/SB	MAT 343	CHM 341	HU/SB
BME 331	BME 370	BME 300	IEE 380	HU/SB
BME 413/23	BME 417	TE‡	HU/SB	HU/SB
TE	BME 490	TE	CSE 100	

CHM 114*	BME 100	MAT 265	PHY 121/122	HU/SB
BME 188**	ENG 105	MAT 266	PHY 131/132	HU/SB
BME 200	CHM 231†	MAT 267	EEE 202	
BME 235	BME 318	MAT 275	BME 350	CHM 341
MAE 212	HU/SB	MAT 343	HU/SB	
BME 331	HU/SB	BME 300	IEE 380	
BME 413/23	BME 417	TE‡	CSE 100	
TE	BME 490	TE	BME 370	

Table 4c is the most appropriate for Honors students to follow. It takes the Honors Seminar into account as elective in the first two years, suggests the Physics classes in the semesters when the Honors section is offered, and includes the Honors class for the English requirement.

*CHM 114 or 116; **BME 111/112 or BIO 188; †CHM 231/235 or 233/237; ‡BME 434, 418 or 419.

Table 5: Spring Semester Junior Year

CHM 114*	ENG 105	MAT 265	BME 100	PHY 121/122
BME 188**	CHM 231†	MAT 266		PHY 131/132
BME 200	EEE 202	MAT 267	CHM 341	
BME 235	BME 318	MAT 275	MAE 212	HU/SB
BME 331	BME 370	BME 300		BME 350
IEE 380	MAT 343	CSE 100	HU/SB	HU/SB
BME 413/23	BME 417	TE‡	HU/SB	
TE	BME 490	TE	HU/SB	

Class List Key:
BME 100: Introduction to Bioengineering
BME111/112 or BIO 188: Biology for Engineers or General Biology
BME 200: Conservation Principles
BME 235: Physiology for Engineers
BME 318: Biomaterials
BME 331: Transport Phenomenon
BME 370: Microcomputer Applications
BME 300: Intermediate Design
BME 350: Signals and Systems
BME 413/423: Bio-instrumentation
BME 417: Capstone Senior Design I
BME 490: Capstone Senior Design II
CHM 114: General Chemistry I
CHM 116: General Chemistry II
CHM 231: Physical Chemistry
CHM 341: Organic Chemistry
CSE 100: Elementary C++ Programming
EEE 202: Circuits I
ENG 105: English Composition
IEE 380: Statistics
MAE 212: Mechanics (Statics and Dynamics)
MAT 265: Calculus I
MAT 266: Calculus II
MAT 267: Calculus III
MAT 275: Differential Equations
MAT 343: Linear Algebra
PHY 121/122: Physics I: Mechanics
PHY 131/132: Physics II: Electricity and Magnetism
TE: Technical Elective
HU/SB: Humanities/Social and Behavioral Sciences Elective

*CHM 114 or 116; **BME 111/112 or BIO 188; †CHM 231/235 or 233/237; ‡BME 434, 418 or 419.

Appendix B: International University and Course Options

Table 6: Biomedical and Biotechnology Bachelor's Programs Classes Offered at select ITESM campuses*

Fall	Spring
Intro to Engineering Physics I Mathematics for Engineers I Cellular Biology and Genetics Molecular Genetics Intro to Computation Biology Chemistry	Physics II Mathematics for Engineers II Structure and Function (+lab) Homeostasis Genetics Organic Chemistry
Analysis and verbal expression workshop Mathematics for Engineers III Structure and Function II (+lab) Homeostasis II Circuits I Molecular Biology Mass "Balance" (Transfer) Probability and Statistics	Biomechanics Computation I Electricity and Magnetism Differential Equations Mathematics for Engineers IV Circuits II Energy "Balance" (Transfer) Thermodynamics Numerical Methods
Biomaterials Computation II Verbal Expression in the professional env. Instrumental Chemistry Electronics Equilibrium Thermodynamics	Ethics: Individual and Social Human and Citizen Formation Control Engineering Signals and Systems Applied Electronics
Bioinstrumentation Biomedical Engineering Design Microcontrollers (microcomputers) Human and Citizen Formation II Logic system design (+lab)	Biomedical Engineering Bioethics for engineers I Professional development Human and Citizen Formation Special topics Metabolic Engineering Biosensors Lab
Integrated Project (design) Hospital Administration Bioethics for Engineers II Medical Imaging Human and Citizen Formation III Special Topics	

*Campuses with these classes: Mexico City, Guadalajara, and Monterrey
Campuses with partial course list: Chihuahua

ITESM programs
The following programs were evaluated as "substantially equivalent" by ABET prior to the initiative to accredit international institutions, many are in the accreditation process now. Note: According to ABET, Substantial equivalency means the program is comparable in educational outcomes, but may differ in format or method of delivery [23].

Campus: Mexico City
B.S. Electronics and Communications Engineering
B.S. Mechanical Engineering with minor in Industrial Engineering
B.S. Mechanical Engineering with minor in Electrical Engineering
B.S. Industrial Engineering with minor in Systems Engineering

Campus: Monterrey *recently accredited
B.S. Industrial Engineering with minor in Systems Engineering
B.S. Mechanical Engineering with minor in Industrial Engineering
B.S. Mechanical Engineering with minor in Electrical Engineering
B.S. Civil Engineering
B.S. Electronics and Communications Engineering
B.S. Chemical Engineering with minor in Industrial Engineering
B.S. Chemical Engineering with minor in Environmental Engineering
B.S. Computer Systems Engineering

Campus: Queretaro
B.S. Computer Systems Engineering
B.S. Electronic Systems Engineering
B.S. Industrial Engineering with minor in Systems Engineering
B.S. Mechanical Engineering with minor in Industrial Engineering
B.S. Electronics and Communications Engineering

Campus: Toluca
B.S. Mechanical Engineering with minor in Industrial Engineering
B.S. Industrial Engineering with minor in Systems Engineering
B.S. Electronic Systems Engineering

Campus: Estado de Mexico
B.S. Computer Systems for Management
B.S. Electronic Systems Engineering
B.S. Mechanical Engineering with minor in Electrical Engineering
B.S. Mechanical Engineering with minor in Industrial Engineering
B.S. Electronics and Communications Engineering
B.S. Industrial Engineering with minor in Systems Engineering

Campus: San Luis Potosi
B.S. Industrial Engineering with minor in Systems Engineering

Modified from complete list from ABET: http://abet.org/subequi.shtml

Table 6: ABET Accredited International Institutions

Location	Institution	Accredited Programs
Cairo, Egypt	The American University in Cairo	Construction Engineering Electronics Engineering Mechanical Engineering
Dubai, UAE	American University in Dubai	Civil Engineeering Computer Engineering Electrical Engineering
Sharjah, UAE	American University in Sharjah	Chemical Engineering Civil Engineering Computer Engineering Electrical Engineering Mechanical Engineering
Ankara, Turkey	Bilkent University	Industrial Engineering
Monterrey, Mexico	ITESM	Chemical Engineering Civil Engineering Engineering Physics Food Engineering Industrial Engineering with minor in Systems Engineering Mechanical Engineering Mechatronics Engineering
Karlsruhe, Germany	University of Karlsruhe	Electrical Engineering Computer Engineering
Kuwait City, Kuwait	Kuwait University	Chemical Engineering Civil Engineering Computer Engineering Electrical Engineering Industrial and Management Systems Engineering Mechanical Engineering Petroleum Engineering

http://www.abet.org/schoolalleac.asp

Table 7: Additional International Universities with Bioengineering programs, not yet accredited.

City, Country	University	BME Website
Paris, France	American University in Paris	http://www.aup.fr/main/about/default.htm
London, England	University College London (UCL)	www.biochemeng.ucl.ac.uk
	Queen Mary University of London	http://mds.qmw.ac.uk/divisions/
Aberdeen, England	University of Aberdeen	www.biomed.abdn.ac.uk/Courses/
Tokyo, Japan	School of High-Technology for Human Welfare Tokai University	http://pfsl.mech.nitech.ac.jp/DeptBME/DeptBME-e.html
British Colombia, Canada	University of British Columbia	http://www.icdl.open.ac.uk/icdl
Guelph, Canada	University of Guelph	http://www.ovcnet.uoguelph.ca/biomed/biomed/html
Christchurch, New Zealand	Christchurch polytechnic institute of technology	http://www.cpit.ac.nz/
Guadalajara, Mexico	La Universidad Autonoma de Guadalajara (UAG)	http://www.uag.mx/
Tel-Aviv, Israel	Tel-Aviv University	http://www.eng.tau.ac.il/Pages/

The websites listed are for their “biomedical engineering” program. Outside of the biomedical engineering programs, each of these universities also offers other technical courses and programs.

Appendix C: Foreign Study Course Description

COURSE DESCRIPTION
BME 494: Independent Study: A Global Experience
Fall 2009

Catalog Description:
Fall, Spring
Provides an opportunity for students to gain experience and knowledge of engineering concepts in a global setting outside of the United States. Students will develop critical skills to understand, adapt to, participate in, engage in and contribute to intercultural interactions.

Prerequisites:
Must be an engineering student; must have completed four semesters at ASU or be within three semesters of graduation at the time of participation.

Textbook(s):
- Recommended: Samovar, Larry, Richard Porter, Edwin McDaniel. Communication between cultures.
- Recommended: Rick Steve's Guide to the destination city.
- Recommended: Lonely Planet Guide to the destination city.

Course Objectives:
- Students will become aware of the differences in communication and interaction style of their host society.
- Students will develop an appreciation for and an understanding of the people in their host country.
- Students will be able to learn the necessary skills to function in a new environment.
  This will include:
    - Proper situational etiquette in the home.
    - Some language skills.
- Students will learn how to travel independently
- Students will be able to apply the above skills in their interactions in their foreign institution.
- Student will be able to apply the above skills when they return home upon completion of the course.
- Students will be able to effectively communicate their experiences abroad to their peers.

In addition, the student should be able to show evidence of:

- Taking an active role in her/his education (e.g., through self-evaluation surveys and journal entries)
- Striving for continuous improvement (e.g., through correcting mistakes and attempting integration)

Topics Covered:

Communication –

Journal assignment: Record observations of examples of verbal and non-verbal communication. Explain the context and your interpretation of their meanings. Evaluate the accuracy of your observations by discussing them with peers, professors, or your host family. Compare and contrast the verbal and non-verbal communication style in your host society with the communication style you were familiar with from home. What is similar and what is different? Evaluate the efficacy of your personal communication style in the new environment.

Contribution of Course to Meeting the Professional Component:
Online discussion board forums.

Relationship of Course to Program Objectives:
Directly related to parts (d), (g), (h), and (i) of the EC2000 criteria.

Person(s) Who Prepared This Description and Date of Preparation:
Prepared by: Sonya Seif-Naraghi Date: April 7, 2008