

## Preparing Engineering Students to Work in a Global Environment: The Union College Model

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### Abstract

It is important for engineering students to develop an international perspective to practice their profession in a society that is becoming increasingly global in scope. A key element in developing this perspective is acquiring an appreciation of, and respect for, other cultures. We believe the best way to do this is through a significant international academic or experiential component in the curriculum that exposes students to a culture other than their own. This will help prepare them to live and work in an international environment. Union College has long had a strong international component in its curriculum. Part of the College's General Education Curriculum is dedicated to providing students with substantial knowledge of another culture. This has been accomplished, in part, by significant study of a foreign language or culture, but primarily through the term abroad program in which students spend a trimester living and studying in a foreign country. Prior to 1996, engineering students were exempt from this part of the General Education Curriculum and few elected to participate in the term abroad program, mainly because of perceived curricular constraints and a failure to appreciate the ultimate importance of such an experience to their personal and professional futures. However, as part of a major revision of the engineering curriculum that was implemented for the entering freshman class of 1996, all engineering students are required to satisfy this part of the curriculum. Since then, additional international study programs have been developed. These include an engineering exchange program, a "mini" or concentrated term abroad during the term break, an international term-in-industry, and the "international virtual design experience". Now engineering students have a variety of options from which to choose that will help them to develop the ability to function and interact with people in a foreign culture. This paper describes these different programs and discusses the process used to establish and support them.

### Introduction

In his defining book on the topic, Friedman<sup>1</sup> describes globalization as the international system that replaced the Cold War system. Globalization is the integration of capital, technology, and information across national borders, in a way that is creating a single global market. Phillips<sup>2</sup> points out that it is engineers who are mainly responsible for bringing about the new era of globalization through technological developments, especially the development of computers and high speed communication networks. It is ironic that we as engineering educators, now find ourselves in a catch-up situation to produce engineering graduates for the 21<sup>st</sup> century who can work and live in this environment. The growing global nature of the engineering profession, clearly, has made it necessary for engineering students to develop an international perspective to be able to practice their profession in a society that is becoming increasingly complex and global in scope. This need has been clearly articulated, for example, by Jones et al.<sup>3,4</sup>, and the

engineering education community has responded by devising strategies in engineering curricula that allow the students to develop more of a global perspective. Throughout the 1990's more engineering departments at colleges and universities have developed a variety of programs to address these needs<sup>5-12</sup>. Phillips<sup>2</sup> points out the role of ABET in helping to bring this about, especially with the adaptation of new engineering accreditation requirements of EC 2000. Part of the new criteria requires engineering programs to demonstrate that their graduates have the broad education necessary to understand impact of engineering solutions in a global and societal context<sup>13</sup>.

A key element in developing a global perspective is acquiring an appreciation of, and respect for, other cultures. We believe, as many others do, that the best way to do this is through a significant international academic or experiential component in the curriculum that exposes students to a culture other than their own. This is the most effective way to help prepare them to live and work in an international environment.

Union College has a long history of a strong international component in its curriculum. This comes out of the General Education Curriculum, major goals of which are to give students a surer grasp of the heritage represented by the western culture and a better knowledge of foreign cultures. The latter is accomplished through a part of the program titled Other Languages, Other Cultures which involves (1) significant study of a foreign language or culture through coursework at Union or (2) an international term abroad program in which students spend a trimester living and studying in a foreign country. Prior to 1996 over 50 % of Union students elected to fulfill the requirement by option 2. Also prior to 1996, engineering students at Union College, comprising about 15% of the student population, were completely exempt from this part of the General Education Curriculum. Few engineering students elected to (or were not advised to) participate in the term abroad program, mainly because of perceived curricular constraints and a failure to appreciate the ultimate importance of such an experience to their personal and professional futures.

In the early 1990's the engineering program at Union College undertook a major effort to design an engineering curriculum for the 21<sup>st</sup> century. This was done with the help of a major grant from the GE Foundation (now GE Fund). Part of this effort was directed at taking advantage of the existing strengths of the technical side of the program but moreover, capitalizing on the fact that we had in place an engineering program taught in a liberal arts environment at an institution with a strong international component in the curriculum. As a result, in the fall of 1996 a new engineering curriculum was implemented<sup>14</sup>. The new curriculum had several new elements that were consistent with the new ABET accreditation criteria that were emerging at that time. A major part of the curriculum change involved making a bold commitment to require all engineering students to satisfy the full General Education Requirements, including the requirement of Other Languages, Other Cultures. Concurrently, we were selected as one of the second round of pilot programs to undergo accreditation review under the new EC 2000.

At the outset of the new program, students had three options to fulfill the requirement. The first was to complete a sequence of three courses in a foreign language. The second was to complete three courses in one of three Cultural Diversity Concentration areas: East Asian Studies, Latin American Studies, and Africana Studies. The third option involved a spending term abroad,

including completing any prerequisite language requirement. The engineering faculty felt strongly that the intent of the new requirement for engineering students was for them to have a foreign experience off campus. Consequently, we emphasized the third option and encouraged students to pursue a term abroad. The first two options still remain as valid choices.

The term abroad, discussed in more detail below, involves students completing part of their curriculum at one of many foreign institutions. Since these programs did not have to accommodate many engineering students in the past, the ones established were at mainly non-technical foreign institutions. So the courses available were primarily in the liberal arts. It was our goal to develop different options for international programs to provide flexibility and variety to what was available and to work in other attributes we felt were important to the program. These included having programs with technical content, elements of multidisciplinary teamwork, including merging engineering and the liberal arts, and use of distance learning.

We immediately began to develop and implement additional international study programs which helped better meet the needs of engineering students. These include an engineering exchange program, "international virtual design experience", a "mini" or concentrated term abroad, and an international term-in-industry. Now engineering students have a variety of options from which to choose that will help them to develop the ability to function and interact with people in a foreign culture. The remainder of this paper describes these different programs, discusses some of the administrative issues involved in supporting them, and presents results on the student participation and distribution in these programs.

### Term Abroad Program

Engineering students at Union can satisfy the international requirement by partaking in a Union College term abroad. In the term abroad program a Union College faculty member accompanies a group of Union students to a foreign country. There are currently twenty such programs at Union College and we have recently expanded under a Andrew W. Mellon Foundation grant to include a collaboration with Hobart William Smith on four new term abroad programs.

The programs in Austria, Brazil, China, France, Germany, Israel, Italy, Japan, Kenya, Mexico, and Spain include the study of language and a broad examination of the history, literature, art and politics of the region. In England, Greece and Kenya each program consists of a Union College course appropriate for the country and two courses designed to develop a knowledge of history, literature, art, and politics of the region. In the Study of National Health Systems, students are engaged in an intensive ten week field study of health care institutions in England, Holland and Hungary. Students take 3-4 courses while on a term abroad. In most of the programs, one of the courses is taught by the resident Union professor, and the others by local professors chosen for their particular expertise. The students are typically housed with a local family or in an international dorm and participate in the normal cultural life of the community.

Many of the term abroad programs have prerequisite language courses which make them difficult for engineering students to take unless they have a strong language background from high school. However, some of the programs have only a single or no pre-requisite language course (Italy, Japan, China, Israel, England) that fits better with the engineering students'

schedules. In general, the engineering students can satisfy two of their general education requirements with the courses taken on a term abroad and take the third course as a free elective. Some students complete courses for a minor while on term abroad.

### International Exchange Program

Union College also offers an International Exchange Program. These one-term or one-year international academic exchanges have been developed with universities in Wales, the Czech Republic, and India as a means of bringing international students to Union and giving Union students an opportunity to study in an international environment. Under this program no Union faculty member accompanies the students; rather, a staff member at the host institution is responsible for the Union students.

These exchange programs do not require foreign language competency since all courses are taught in English. Students may be required to include language and cultural studies in their programs overseas. Generally, the students substitute equivalent engineering courses at the foreign university for those courses they would have taken at Union, satisfy some of their General Education requirements, and take some free electives courses.

### International Virtual Design Experience

It became apparent that due to academic, extracurricular, family, or employment conflicts, that it is not practical for all students to spend three months to a year out of the country. This led to the development of additional international programs that would require less time out of the country, yet still provide students with a significant international experience. One of the new programs developed to help students satisfy the international requirement of the Union College engineering program is the International Virtual Design Studio (IVDS) project<sup>15,16</sup>.

The IVDS project provides an international collaborative design experience for engineering students widely separated by time, geography, and culture through the use of various electronic communications technologies via the Internet. The IVDS program was first piloted in the Fall of 1996 in collaboration with the Middle East Technical Institute (METU) in Ankara, Turkey. Students at Union College are paired with students at METU to form design teams. These teams are provided with a design challenge and have 16 weeks to design a solution to the challenge, implement the design, and enter the resulting design into a competition held in Turkey. This program is now in the 5<sup>th</sup> year and has been expanded to include ESIGELEC (Ecole Superieure d'Ingenieurs en Genie Electrique) in Rouen, France. Discussions are currently under way with other institutions world wide to set up similar programs.

Although the IVDS projects only require students to spend a short period of time out of the country, they do require engineering students to confront other cultures for a much longer period of time. The student interactions prior to the actual international visit sensitize students to the need to understand other cultures from an engineering perspective. Engineering projects performed in the international arena still have budgets and deadlines; however, in addition engineers must consider the national and cultural interest of their teammates when working together and arriving at an effective and optimal design solution.

## Mini Term Abroad

The mini term abroad provides the students with a concentrated three-week immersion in a foreign culture. It is designed not only to provide students with a foreign experience but to build interdisciplinary interaction between engineering students and liberal arts students. In this program each of approximately eight engineering students are teamed with a liberal arts partner, typically from the social sciences. The program is oriented around a central focus or project, typically a characteristic engineering or technical aspect of the country that also has a major impact on the peoples of that society. The liberal arts students assist the engineers in assessing the political, cultural, economic, historical, environmental and ethical aspects of the problem, while the engineering students assist the liberal arts students in understanding the engineering aspects of the project. The students travel abroad and stay for three weeks and live with a homestay family. The students are accompanied by a pair of Union faculty, an engineer and a social scientist. An attractive feature of the mini term is that it is done outside of the academic year, either during the December break between fall and winter terms or in July, after the spring term. Consequently, the students' academic schedule is not interrupted. Students attend seminars on the language and culture of the country in preparation for the experience.

This program was first developed with a Christian A. Johnson Endeavour grant which is continuing to support the development of additional mini term programs. The current programs include Water Resources of Sao Paulo Brazil, Water Resources of Queensland, Australia, medical technology in Scotland, Electric Power in New Zealand, and Mini Term at ESIGELEC France.

## International Term-in-Industry

This program involves students working for at least an academic term in an international industrial or engineering environment. The work assignment must encompass significant time spent in an international workplace and substantial interaction with a multinational or foreign workforce. This program is still in the early stages of development and admittedly the most administratively intensive to develop. So far only a few students have done this option. These opportunities presented themselves after the students first did an earlier co-op with a multinational company in the US. The company then arranged to have the student do a second co-op at one of their foreign facilities. Even though only a few students have done this option so far, the experiences have been very positive. In fact, one graduate has accepted a position, and will be returning to the site of his international co-op assignment to work and live for at least two years.

## Program Administration

The programs are administered by the Director of International Programs. Faculty have an important role in the process including leading terms abroad, developing and leading mini terms, and advising students by helping them plan out their program. A team of ME and EE faculty oversee the International Virtual Design Studio and advise the student projects.

Students must apply to participate in each of the international programs. The selection process is competitive. Two academic terms before the scheduled experience, the students must submit a written application along with a one-page essay. Some of the more popular experiences such as the terms in York, Florence, and Seville get numerous applicants and become quite competitive. Sometimes students must choose an alternative destination as a second choice.

This program requires careful planning on the part of the students and close consultation with their academic advisor. Early in the sophomore year, students must select and prepare for that alternative most appropriate to the individual's personal and professional objectives. The preparation sometimes entails fulfilling any language prerequisite requirements. The engineering departments have tried to build flexibility into their curricular schedules to help facilitate the students' completing an international experience. For example, in mechanical engineering the fall term of the junior year is designated as the preferred term for students to do a term abroad or engineering exchange, since the fall term has the largest number of term abroad and exchange opportunities. This term is free of any required engineering courses. If a student chooses to participate in a program that runs during another term, their schedule can usually be accommodated. This, again, requires careful planning with the academic advisor.

Union College operates on a trimester calendar. The international curricular component for engineering students is better suited to this system than to a semester system. This way students who travel abroad are gone from campus only 1/3 of the academic year as opposed to 1/2 year. They take a 3-4 course load while abroad which usually allows them some time to travel within the country and to nearby countries.

## Results

Figure 1 shows a plot of the percentage of engineering students who have an international experience (IE) versus the year of graduation for the past seven years. Prior to the development of the new curriculum only about 6% of the engineering students went on a term abroad (the only IE option at the time). The new curriculum was implemented with the group of students who started in 1996 (and graduated in 2000). At that time we began to add more IE options for all engineering students. The percentage of students with an IE jumped to 26% for the class of 1997 and steadily increased to 34% for the class of 1998 and 40% for the class of 1999. None of these students was required to have the IE; however as they became available more engineering students participated in them. For the class of 2000, the first class with the requirement, approximately 90% of the students participated in an IE experience. The remaining 10% satisfied the requirement by taking three courses in a language or a three course cultural diversity sequence. This includes mainly the non-traditional students who find it difficult to travel for personal/work related reasons.

Figures 2 and 3 show how the international experiences are distributed among the six options, organized by graduation class year. Prior to 1997 the term-abroad was the only option available. Figure 2 plots percentage of IE options in each category and Figure 3 show the actual number of students. For the class of 2000 we see a fairly even distribution of students among the term-abroad, exchange and mini-term options. The largest percentage of students (30%) choose the mini term abroad option, with 25% doing a regular term abroad and 21% going on an exchange

program. Only 2% of the students participated in the international coop program. Preliminary data for the class of 2001 shows an increase in the percentage of students taking the regular term abroad option (about 33%) and the exchange option (30%), and fewer, only 24%, choosing the mini-term abroad option.

## Conclusion

We have addressed the need to prepare engineering students for the growing global nature of the engineering profession by introducing a required international component to the engineering curriculum. A number of different options have been developed with the main emphasis on providing the opportunity for an international experience for the students. The different programs include other important attributes to a well-rounded engineering education including engineering design, multicultural/multidisciplinary teaming, and exposure to the liberal arts. A foreign study experience can be a valuable part of the education of an engineer by helping to develop a global perspective, acquire an appreciation of cultural differences, and build confidence. All of these should greatly enhance the opportunities available to the student upon graduation.

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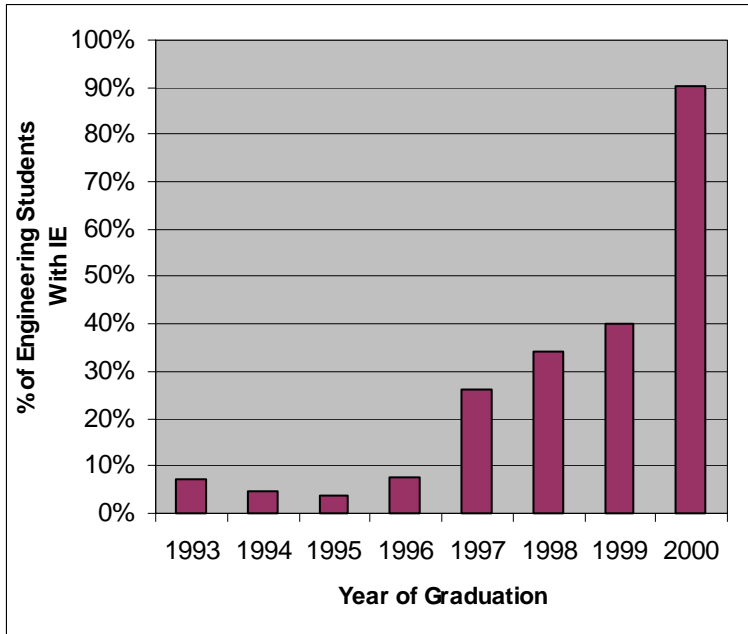


Figure 1. Percentage of engineering students partaking in international experience (IE) by class year.

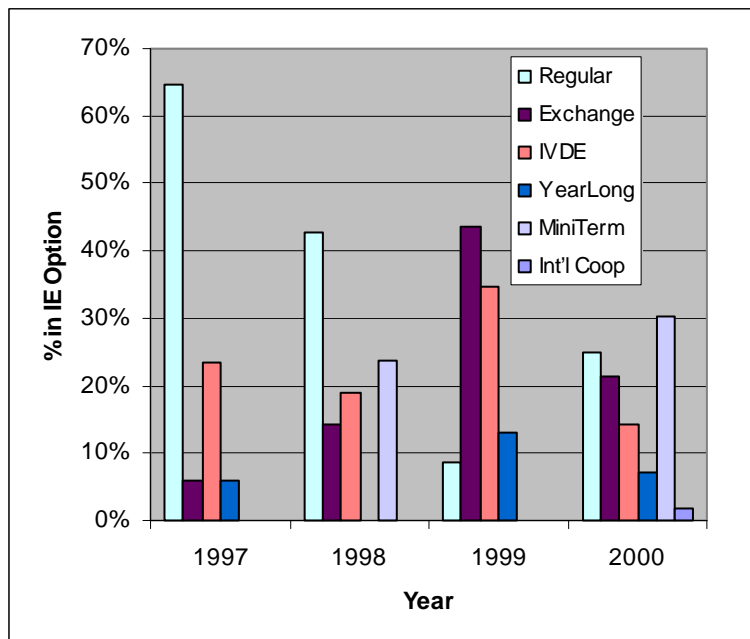


Figure 2. Distribution of international experience options by graduation year.

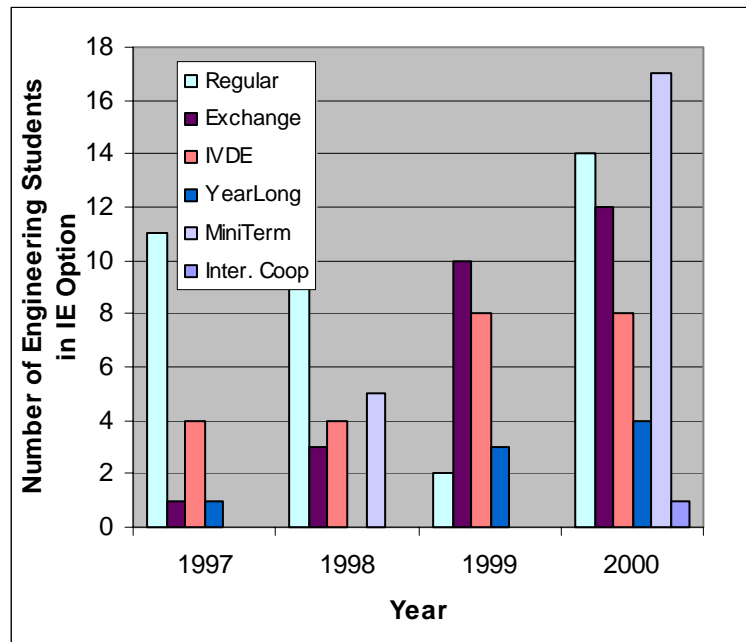


Figure 3. Number of students in each international experience option by graduation year.