A descriptive study of the barriers to study abroad in engineering undergraduate education and recommendations for program design
by Sabine Christine Klahr

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University

Abstract:
This study analyzed and compared the program designs of international exchange and internship programs for engineering students in the United States and the European Union (E.U.) as well as the extent to which these programs have removed barriers to study abroad. The purpose of this study was to provide recommendations for the design of international programs in the U.S. that would increase the proportion of engineering students who choose to study or intern abroad. Coordinators of international programs in engineering were surveyed about their perceptions of program success and a number of variables related to program design. A Chi-Square Test of Independence of (A) program success and (B) European and U.S. programs (i.e. institution location) cross-tabulated with all other variables and each other indicated those variables that contribute to the success of programs and those variables that are associated with either U.S. or European programs. In addition, all programs were described and the answers to open-ended survey questions were analyzed quantitatively. The analyses indicated that European programs tend to be more successful in implementing study/intern abroad programs for engineering students than U.S. programs. The elements of program design contributing to the greater success of European programs and the success of specific U.S. programs were described. In addition, the characteristics of overall successful programs (U.S. and E.U. data combined) were explained. The results indicated that successful programs tend to: (1) be promoted by the college and/or departments of engineering, (2) offer study/intern abroad opportunities in English-speaking settings, (3) award full credit at the home institution for required engineering courses completed at the host institution, (4) offer scholarships and financial aid for participation in the program, (5) require participating students to have completed their second year of university course work prior to applying to the program, and (6) eliminate the barrier “stringent curricular design, sequencing, and requirements reflecting accreditation standards.” In addition, programs tend to be successful at institutions that require foreign language study for an undergraduate degree in engineering. Recommendations were provided for the design of U.S. programs that would increase engineering student participation in international experiences.

A DESCRIPTIVE STUDY OF THE BARRIERS TO STUDY ABROAD IN ENGINEERING UNDERGRADUATE EDUCATION AND RECOMMENDATIONS FOR PROGRAM DESIGN

by

Sabine Christine Klahr

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Doctor of Education

MONTANA STATE UNIVERSITY-BOZEMAN
Bozeman, Montana

August 1998

APPROVAL

of a thesis submitted by

Sabine Christine Klahr

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

Dr. John Kohl — Signature — Date: 7/16/98

Approved for the Department of Education

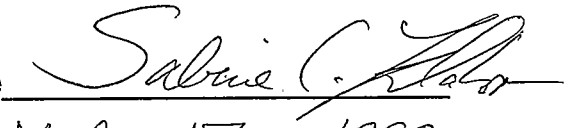
Dr. Gloria Gregg — Signature — Date: 7/16/98

Approved for the College of Graduate Studies

Dr. Joseph Fedock — Signature — Date: 7/23/98

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a doctoral degree at Montana State University-Bozeman, I agree that the Library shall make it available to borrowers under rules of the library. I further agree that copying of this thesis is allowable only for scholarly purposes, consistent with "fair use" as prescribed in the U.S. Copyright Law. Requests for extensive copying or reproduction of this thesis should be referred to University Microfilms International, 300 North Zeeb Road, Ann Arbor, Michigan 48106, to whom I have granted "the exclusive right to reproduce and distribute my dissertation in and from microform along with the non-exclusive right to reproduce and distribute my abstract in any format in whole or in part."

Signature 

Date July 17, 1998

Für meinen Bruder,
Henning (Henry) Klahr,
dem nie Hoffnung auf
ein besseres Leben gegeben wurde
und der allein in der Welt war

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my graduate committee for assisting me in completing all of the requirements for my degree. My graduate committee included: Dr. John Kohl, Dr. Eric Strohmeyer, Dr. Norman Peterson, Dr. Michael Wells, and Dr. Ralph Brigham. In addition, I would like to thank Dr. Norman Peterson for his assistance in defining a dissertation topic, for his sincere interest in the content of my study, and his support and encouragement throughout the process of completing my dissertation.

I would also like to thank the staff in the Office of International Programs at MSU-Bozeman who helped me through "the doctoral candidate experience" by offering support and encouragement. In addition, they listened and offered advice during periods of frustration and impatience.

Finally, I would like to express my deepest gratitude to my friends who always "knew" that I would complete my degree, to Greta who provided financial support as well as encouragement, and, of course, to Roger who always believes in me and whose support was essential.

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

LIST OF TABLES

LIST OF TABLES - Continued

Table Page

ABSTRACT

This study analyzed and compared the program designs of international exchange and internship programs for engineering students in the United States and the European Union (E.U.) as well as the extent to which these programs have removed barriers to study abroad. The purpose of this study was to provide recommendations for the design of international programs in the U.S. that would increase the proportion of engineering students who choose to study or intern abroad. Coordinators of international programs in engineering were surveyed about their perceptions of program success and a number of variables related to program design. A Chi-Square Test of Independence of (A) program success and (B) European and U.S. programs (i.e. institution location) cross-tabulated with all other variables and each other indicated those variables that contribute to the success of programs and those variables that are associated with either U.S. or European programs. In addition, all programs were described and the answers to open-ended survey questions were analyzed quantitatively. The analyses indicated that European programs tend to be more successful in implementing study/intern abroad programs for engineering students than U.S. programs. The elements of program design contributing to the greater success of European programs and the success of specific U.S. programs were described. In addition, the characteristics of overall successful programs (U.S. and E.U. data combined) were explained. The results indicated that successful programs tend to: (1) be promoted by the college and/or departments of engineering, (2) offer study/intern abroad opportunities in English-speaking settings, (3) award full credit at the home institution for required engineering courses completed at the host institution, (4) offer scholarships and financial aid for participation in the program, (5) require participating students to have completed their second year of university course work prior to applying to the program, and (6) eliminate the barrier "stringent curricular design, sequencing, and requirements reflecting accreditation standards." In addition, programs tend to be successful at institutions that require foreign language study for an undergraduate degree in engineering. Recommendations were provided for the design of U.S. programs that would increase engineering student participation in international experiences.

CHAPTER 1

INTRODUCTION

Internationalization of higher education is taking place in a variety of ways in the United States. Universities are internationalizing through recruitment of international students, student and faculty exchange programs, short-term study abroad opportunities, collaboration with overseas universities in teaching and research, and incorporation of international perspectives in the curriculum. Providing international exchange opportunities for American students is imperative in the development of an international dimension in higher education (Burn 1980; *Exchange 2000* 1990; McLean 1990; Allaway 1991; Berchem 1991; Briscoe 1991; Merkur'ev 1991; Seidel 1991; Harris 1993). All students, regardless of their majors, must develop global competency to succeed in today's world (Spofford 1990). A highly effective tool in enhancing students' global competency is participation in study abroad (Spofford 1990; King and Young 1994). Students who study abroad not only develop international skills which are increasingly necessary in all professions, they also benefit personally from living, studying, and traveling in a different country. Study abroad provides a unique opportunity for students to grow personally as well as professionally.

In the United States, the percentage of undergraduate students in engineering who study abroad is disproportionally small compared to students in other disciplines (Burn 1988; Johnston and Edelstein 1993; King and Young 1994; *Open Doors 1996/97*). Approximately 2 percent of all U.S. undergraduate students study abroad. In 1995/96, 35 percent of American undergraduates who studied abroad majored in the social sciences and humanities (*Open Doors 1996/97*). The second largest group of students who went abroad to study (14 percent) majored in business (*Open Doors 1996/97*). By comparison, students in engineering, physical and life sciences, and math and computer sciences combined accounted for only 10 percent of all undergraduates who studied abroad in 1995/96 (*Open Doors 1996/97*). Approximately 2 percent of all undergraduates who study abroad major in engineering (*Open Doors 1995/96*). In European countries, the percentage of students majoring in technical disciplines who study abroad is significantly larger than it is in the United States: 18% in the UK, 24% in Spain, 25% in Germany, 19% in France, and 26% in Italy (*Open Doors 1994/95*). In Europe, study abroad is defined as studying in another country within Europe and outside of Europe.

It has become increasingly important for American engineering students to acquire international skills, as the engineering profession increasingly demands interaction with international colleagues as well as overseas travel, and study abroad provides a most effective means of achieving those skills.

International skills or global competency include fluency in a foreign language, intercultural understanding, expertise in intercultural communication, and a global perspective. Unfortunately, most engineering students in the United States are not acquiring essential international skills required in their future professional careers, because they do not study abroad (Wakeland 1989; O'Brien 1991; Johnston and Edelstein 1993; King and Young 1994).

The fact that American engineers do not learn how to effectively communicate with colleagues from other nations and lack awareness of other cultures and world events, will ultimately put U.S. research and development of technology at a serious disadvantage (Wakeland 1989). The United States is playing a key role in the global economy and is increasingly competing with other nations in the production of technically based goods. American engineers are increasingly involved in international projects and interactions with colleagues from other cultures. Companies in the U.S. involved in the production of technical goods need employees that are able to effectively interact with an international community. In addition, several nations have surpassed the United States in the research and development of some new technologies (Goodwin and Nacht 1991). American researchers must be able to go overseas and learn from their colleagues in other countries. If the number of culturally competent U.S. engineers does not increase, U.S. efforts to compete successfully in global markets will be seriously restricted (Wakeland 1989).

Various reasons for the lack of participation in international exchange by American engineering students have been documented. In addition to general barriers to study abroad encountered by students in all majors (Spofford 1990; Aitches 1992), engineering students face a number of specific barriers related to engineering education. These barriers include: (1) problems involving credit transfer of courses completed overseas (2) lack of support and encouragement to study abroad by engineering faculty and administrators, (3) lack of emphasis on foreign language and global awareness courses in engineering education, (4) stringent curricular design, sequencing, and requirements reflecting accreditation standards, (5) lack of funding to develop programs and/or promote engineering student participation, and (6) students' misconceptions of study abroad (Grandin 1989; Pang 1989; Goodwin and Nacht 1991; O'Brien 1991; Johnston and Edelstein 1993; King and Young 1994; Weinmann 1995; Weinmann and Weinmann 1996; DeWinter 1997).

A number of study abroad offices and engineering colleges and departments at higher education institutions in the United States have developed international programs for engineering undergraduates (Pang 1989; Wakeland 1989; Grandin 1991; Goodwin and Nacht 1991; Aigner et al. 1992; Weinmann 1992; Johnston and Edelstein 1993; Weinmann and Weinmann 1996). However, the proportion of American engineering students who participate in study abroad has not increased significantly over the past ten years. In 1985/86,

1.6 percent of all students studying abroad were engineering majors and in 1995/96 it was 2.2 percent (*Open Doors 1995/1996 and 1996/97*). During those ten years, the percentage of engineering students fluctuated between 1.3 and 2.3 and the average was 1.7 percent.

This study describes the program designs of international exchange programs for engineering students and the extent to which these programs have removed barriers to study abroad. Based on successful programs in the United States and Europe, this study provides recommendations for the design of an international exchange program in engineering that would maximize student participation.

Problem Statement

This study describes and compares the program designs of international exchange programs for engineering students in the United States and the European Union as well as the extent to which these programs have removed barriers to study abroad.

Importance of the Study

Although a number of universities in the United States are offering international programs and study abroad opportunities for engineering students, the number of engineering majors who participate in study abroad remains disproportionally low compared to students in other fields of study. Studying

abroad provides students with a highly effective means of gaining the global competence needed to live in an interdependent global world and required by their future professions (Spofford 1990). Since it has become especially important for American engineers to have international skills and perspectives, there is a serious need to increase the number of engineering students who study abroad. This study focuses on analyzing the program designs of international programs for engineering students, determining to what extent international programs in engineering have removed barriers to study abroad, and recommending what can be done to facilitate study abroad for a greater number of American engineering students.

Definition of Terms

- *Internationalization:* refers to the development of an international dimension throughout the entire organizational structure of a higher education institution. Rudzki (1995) defines "internationalization" as "a defining feature of all universities, encompassing organizational change, curriculum innovation, staff development, and student mobility, for the purposes of achieving excellence in teaching and research."
- *Study abroad* and *international exchange*: although "international exchange" is typically defined as a reciprocal bilateral movement of

students between two overseas universities, the term is used here as interchangeable with the term "study abroad" and pertains to students spending a quarter, semester, or academic year studying or interning (or both) in a foreign country.

- *International skills* and *global competence*: are interchangeable terms and include intercultural communication and understanding, global awareness, and communicating in a foreign language.
- *Successful programs:* in the context of this study, are defined as programs that are perceived as successful by program directors/coordinators considering factors such as the numbers of engineering students studying abroad through each program, the quality of the study abroad experience, high morale of returned students, engineering faculty and administrator involvement in the program.

Questions Answered by This Study

1. Have international exchange programs for engineering undergraduates in the United States removed barriers to study abroad as perceived by the directors/coordinators of these programs? The barriers include: (1) problems involving credit transfer of courses completed overseas (2) lack

of support and encouragement to study abroad by engineering faculty and administrators, (3) lack of emphasis on foreign language and global awareness courses in engineering education, (4) stringent curricular design, sequencing, and requirements reflecting accreditation standards, (5) lack of funding to develop programs and/or promote engineering student participation, and (6) students' misconceptions of study abroad.

2. How have successful American and European international programs for engineering undergraduates removed barriers preventing students from studying abroad?
3. What factors are essential in the design of successful American and European international engineering programs as perceived by the directors/coordinators of these programs?
4. How do European and U.S. programs compare with respect to program design and removal of barriers?
5. What are the recommendations of program directors/coordinators for the design of international programs for engineering undergraduates?

CHAPTER 2

LITERATURE REVIEW

Internationalization of Higher Education in the United States

The importance of internationalizing higher education in the United States has been widely documented (Burn 1980; Klitgaard 1981; Leinwand 1983; Burn 1988; DiBiaggio 1988; Smuckler and Sommers 1988; *Exchange 2000* Report 1990; Briscoe 1991; Smelser 1991; Kerr 1991; Goodwin and Nacht 1991; Merkur'ev 1991; Aigner 1992; Harari 1992; Mauch and Spaulding 1992; Harris 1993; Johnston and Edelstein 1993; American Council on Education 1998). The key reasons cited by these authors for internationalizing higher education in the United States are: (1) ensuring the United States' successful participation and competition in the global economy; (2) improved political interactions of the United States with other nations; (3) collaboration of the United States with other nations in addressing global environmental, economic, health, and social problems; (4) learning about research and development of new technologies in other countries and applying these technologies in the United States to avoid ignorance of new technologies and "reinventing the wheel;" (5) increased mobility of people through migration and tourism to and from the United States;

and, (6) taking into account that the basic purpose of higher education institutions is their enhancement and distribution of universal knowledge.

Although the United States is often at the center of world events and is becoming increasingly interconnected with the rest of the world, aspects of American higher education have not incorporated an international dimension (Goodwin and Nacht 1991). American students can complete a four-year degree without any exposure to international topics, entering their professions or graduate school lacking global competence. Leinwand (1983) explained that in today's world a person cannot be considered well-educated if he or she does not have an understanding of global issues. Furthermore, Harari (1992) stated that "since the students we now help educate will live in a highly interdependent and multicultural world it is obvious that irrespective of the narrower academic and professional skills acquired by these students they will need also to acquire a reasonable degree of knowledge and skills with respect to the interconnectedness of peoples and societies and cross-cultural communication." It is the responsibility of higher education to develop internationalized curricula and programs; otherwise, American students will emerge from universities lacking essential professional skills and knowledge. This will put the United States at a serious disadvantage in the future compared to other nations (Goodwin and Nacht 1991).

Rudzki (1995) defined internationalization as "a defining feature of all universities, encompassing organizational change, curriculum innovation, staff development and student mobility, for the purposes of achieving excellence in teaching and research." The process of implementing internationalization has been analyzed and described from different perspectives and at various levels within higher education. Briscoe (1991) reported that internationalization of a small college in Iowa was accomplished through faculty and student exchanges, recruiting international students, and foreign language study. Merkur'ev (1991) explained that internationalization should occur through student exchanges, foreign language study, international cooperation of universities in establishing curricula, inter-university information networks, and joint scientific research and publishing projects. Aigner et al. (1992) stated that internationalization can be achieved through foreign language and area studies, curriculum reform with an international emphasis, study abroad programs, international internships, foreign students, faculty exchanges, international research projects, inter-institutional cooperation, development projects, international activities at the university, faculty development with an international focus, aid to the private sector in international activities, and funding for international projects. These authors as well as Harari (1990) emphasized that internationalization must occur through the initiation of a variety of activities integrated throughout all units of a university. Such integration is not only possible, but also necessary because all

academic disciplines have an international dimension (Carter 1994). One cannot be completely knowledgeable in a subject without being able to understand it in an international context. Edelstein and Johnston (1993) observed that the three characteristics of most successful internationalized programs are that they have been institutionalized, they are multi-dimensional and well-integrated, and that they have depth and sufficient intensity to provide effective global competence to a large number of students and faculty.

A number of authors (Burn 1980; *Exchange 2000* Report 1990; Berchem 1991; Allaway 1991; Seidel 1991; Kauffmann et al. 1992; King and Young 1994; Miller 1994) have addressed the importance of student exchanges in particular to the process of internationalization. Miller (1994) explained that international student exchanges represent "an excellent technique for quickly and efficiently introducing an international dimension into the curriculum and the life of the institution." Study abroad opportunities and overseas internships provide students with "hands-on" international experience that cannot be gained on campus at the home institution (Spofford 1990). Berchem (1991) stated that the internationalization of higher education cannot be achieved without increasing the international mobility of students. Merkur'ev (1991) explained that student exchanges are essential in providing students with the opportunity to become familiar with a variety of "scientific schools of thought," to experience various teaching and research techniques, and to immerse themselves in another culture

and thereby gaining a more profound understanding of the world. In the *Exchange 2000* Report (1990) one of the recommendations for enhancing internationalization in the United States is to substantially increase student exchange opportunities, because "the best resource the nation can have in facing its international challenges is a very large number of highly trained people with first-hand knowledge of another culture and hands-on experience working and learning in it."

Patterns of U.S. Students Studying Abroad

According to *Open Doors1996/97*, the total number of U.S. undergraduates studying abroad for academic credit increased from 48,483 to 89,242 over the past ten years. However, this seemingly large increase in numbers needs to be put in perspective. The increase occurred mostly during the late 1980's. The absolute numbers of U.S. students studying abroad is relatively small compared to the total number of undergraduates in the U.S. (approximately 2 percent of all U.S. undergraduates study abroad) and the length of time spent abroad is decreasing.

Traditionally, the largest group of U.S. students studying abroad major in the humanities and social sciences whereas the smallest numbers of students studying abroad major in engineering, physical and life sciences, and math or

computer sciences (Burn 1988; *Exchange 2000* 1990; O'Brien 1991; King and Young 1994; *Open Doors 1995/96*; Hoffa 1998). Only 2.2 percent of all U.S. students studying abroad in 1994/95 were engineering majors, 2.1 percent were life sciences majors, 1.2 percent were math or computer science majors, and 6.8 percent were physical science majors (*Open Doors 1995/96*). In the United States/European Union study abroad relationship, a significantly smaller percentage of American students in technical majors study abroad compared to their European counterparts (*Open Doors 1994/95*). According to *Open Doors 1994/95*, the percentage of American students in technical majors (which include majors such as computer science, environmental science, biotechnology, and others in addition to engineering) who studied abroad in Europe in 1993/94 was 9 percent. In 1995/96, this percentage had increased to 10 percent (*Open Doors 1996/97*). In several European nations, of all the students who studied abroad in the U.S., the percentages of students in technical fields in 1993/94 was much larger: 18 percent in the United Kingdom, 24 percent in Spain, 25 percent in Germany, 19 percent in France, and 26 percent in Italy (*Open Doors 1994/95*).

Importance of Internationalizing Engineering Education

Several authors have discussed the necessity of incorporating an international dimension, foreign language instruction, and study/intern abroad

opportunities into engineering and science education (Grandin 1988; Pang 1989; Wakeland 1989; Goodwin and Nacht 1991; O'Brien 1991; Weinmann 1992 and 1995; Weinmann and Weinmann 1996; DeWinter 1997). O'Brien (1991) explained that scientific technology is becoming increasingly important in international political and economic decision-making. If scientists and engineers are not aware of global political and economic events, they cannot effectively address international issues related to health and medicine, environmental degradation, conservation of diversity, world food production, and natural resources extraction. In addition, scientists and engineers need to be able to inform nations' leaders about international technology issues so that those leaders can incorporate this knowledge into decisions affecting their countries and the world.

Grandin (1988), Wakeland (1989), and O'Brien (1991) emphasized U.S. competition in the global marketplace as a key reason for internationalizing science and engineering education. U.S. companies that are involved in the production of technically-based goods are increasingly competing in world markets. These companies need employees who are skilled in intercultural communication, knowledgeable about the world, accustomed to overseas travel, and speak foreign languages. Furthermore, other nations have surpassed the United States in the development of some technologies and American engineers' lack of international skills and perspective is the direct cause of the United States

losing its competitive edge related to these new technologies (Goodwin and Nacht 1991; O'Brien 1991). The U.S. needs scientists and engineers who can effectively collaborate with their peers in other countries in order to learn about new technologies developed there. About ten years after graduation most engineers move into administrative positions within their companies and those positions are often overseas (Pang 1989). Pang (1989) described that "one major oil firm reports having to bring back ninety percent of the American engineers it sends to Southeast Asia within less than a year because of their inability to adapt, either professionally or personally."

Weinmann and Weinmann (1996) and Weinmann (1995) stated that science and engineering graduates must have intercultural communication skills, be able to collaborate and work with their colleagues from other nations, and be able to foster international relationships to advance research and technological productivity. In today's global business environment engineering companies seek employees who speak languages and who have experienced different cultures (Bismuth and Edmundson 1994). However, even engineering graduates who have language skills and prior experience with other cultures may not survive and flourish in a multicultural professional environment (Bismuth and Edmundson 1994). These skills can only be learned through "a live confrontation with reality" (Bismuth and Edmundson 1994) which students experience when studying or interning abroad. Considering the importance of

acquiring global competence, why are engineering undergraduates not studying abroad in greater numbers? To answer this question, barriers to studying abroad imposed by universities, engineering colleges/departments, faculty, and accrediting agencies need to be discussed.

Barriers Preventing Engineering Students From Studying Abroad

A number of barriers prevent engineering students from taking advantage of international exchange opportunities. Weinmann (1992) reported that engineering departments are often limited in their attempts to add an international focus by stringent curricula required by accreditation bodies. Engineering students who want to take a foreign language or other global awareness courses generally have to add extra semesters to their four-year degree (Grandin 1989). This is also the case for time spent overseas. "Structural issues, including curricular design and requirements, transfer of credit and modes of assessment, and academic calendars" (DeWinter 1997) often result in engineering students who have studied abroad to spend additional time attaining their degrees. Students who are not exposed to other cultures, either through foreign language study or global studies courses, are not likely to express a desire to study abroad. Similarly, if studying abroad entails additional semesters and thereby an increased cost of students' degree attainment, it is

unlikely they will be motivated to participate in international exchange. King and Young's (1994) study showed that engineering students believed that their departments' rigid curricula did not allow for time spent studying abroad.

Burn (1980), Grandin (1989), Pang (1989), Goodwin and Nacht (1991), and DeWinter (1997) cited faculty and administrator attitudes as well as tradition as barriers to implementing study abroad opportunities for engineering students. Engineering faculty and administrators who do not directly work with the private sector are not aware of the need for future engineers to gain international expertise. Combined with the tradition of technological disciplines generally not encouraging students to study foreign languages and international topics, faculty and administrators in these disciplines tend to find such courses unnecessary in engineering education. Therefore, engineering students do not receive encouragement to take foreign language and global studies courses and causes them to be unaware that global competence will play an important role in their future professions.

DeWinter (1997) found "uneven mathematical skills" to be a barrier for American engineering students to study abroad in Europe. Since university admission requirements are significantly more stringent in Europe and European students' mathematical skills are higher at the time they enter universities, American undergraduates often lack the necessary mathematical skills to complete engineering courses at European institutions. American engineering

students' lack of necessary mathematical skills as a barrier to study abroad most likely surfaces while students are studying abroad. American students at European universities may realize that they are not able to complete engineering courses due to their lack of mathematical skills and are likely to enroll in non-technical courses. This means that they will have to make up engineering courses at their home institution resulting in those students spending additional semesters to complete their degrees.

Sangster (1994) explained that although many American universities have signed exchange agreements with overseas institutions to promote study abroad of engineering students, these agreements have been difficult, if not impossible, to implement. The reasons for this difficulty to implement engineering student exchanges are credit transfer across international boundaries, differences in the preparation for college and in the length of the engineering degree programs, and the lack of financial resources to develop international exchange programs (Sangster 1994). Several international programs have been developed for students in engineering (Pang 1989; Wakeland 1989; Grandin 1989, 1991; O'Brien 1991; Weinmann 1992, 1995; Sangster 1994; Brennan 1996; Weinmann and Weinmann 1996). Some of these programs involve consortia of universities, some are simple international exchange agreements between American and overseas universities, and some involve a partnership between higher education institutions and private industry. These programs have attempted to remove

traditional barriers preventing engineering undergraduates from studying abroad. However, the small percentage of students in engineering who participate in international exchange has remained constant over the past six years (*Open Doors 1995/96*).

Internationalization of the Business Curriculum as a Model for the Engineering Curriculum

There are parallels between business and engineering education in the U.S. that allow a comparison of the two disciplines with respect to internationalization. Engineers who work in their profession for a number of years typically move into management positions within their companies and require similar skills and knowledge as professionals with a business background. Until the early 1980's the business curriculum in the United States was in a similar position with respect to internationalization as engineering curricula are today. According to Miller (1994), business curricula did not incorporate an international dimension and did not keep up with global economic, social, and political events. American business students did not study abroad because they faced similar barriers as engineering students do today. Today, a large percentage of American students studying abroad are business

majors (*Open Doors 1995/96*) and accreditation standards require the incorporation of international topics and issues in the business curriculum (Harris 1993). Over the past 20 years, American universities and colleges have internationalized business education to a large degree. What can engineering education learn from these advancements in business education to internationalize engineering education?

Harris (1993) discusses that institutions have focused on four basic elements to internationalize their business programs: (1) curriculum in international business, (2) faculty with expertise in international business, (3) collaboration with business and/or government, and (4) international experiences for students. Within the broader context of each institution in Harris' (1993) study, the following factors have also contributed to internationalization: "the role of international students, the importance of institutional support, and the relationship between institutional mission and international business curricula." Miller (1994) agreed that faculty commitment and development, programmatic initiatives, exchange programs, and student internships are essential in the process of internationalization.

Harris (1993) stated that accreditation was one of the most important reasons for institutions to internationalize their curricula. The two major accreditation agencies of business schools have developed standards that require business students to take courses in international business (Harris 1993).

Colleges of business have addressed the issue of faculty expertise and interest by implementing faculty development programs and hiring faculty with international business expertise. Partnerships with industry and government have provided students with internship opportunities in international business. The majority of colleges and universities surveyed by Harris (1993) encourage business students to study abroad and take foreign languages, and at some institutions it is mandatory. All of these factors have contributed to the internationalization of business programs and should be considered with regard to internationalizing undergraduate programs in engineering.

Internationalization of Engineering Education in Europe

As Europe is moving towards a community of nations, European authorities are developing and implementing important programs to enhance student mobility (Maury 1997). Although the European Community has been developing over the past forty years, the nations comprising Europe remain linguistically and culturally distinct. Therefore, the barriers for university students to study "abroad" within Europe (as well as outside of Europe) are similar to those for American students to study overseas. "It is difficult for European education to open up its programs to European neighbors, in order to create a "European label," without losing its own characteristics and traditional national

approaches" (Humily 1997). However, the development and implementation of innovative student mobility programs in Europe are an attempt to enhance European unity in higher education.

Currently, 5 percent of all European students study abroad and the goal of European authorities is 10 percent (Maury 1997). Looking at individual European nations and specific academic disciplines, there are exceptions to these percentages. According to a 1995 Center for Studies in Engineering Education (CEFI) survey of French engineering schools, on average 15 percent of their students spend at least six months abroad (Maury 1997). Considering all French engineering students who study or intern abroad, 59 percent do so in Western Europe, 30 percent in Eastern Europe, 26 percent in North America, and 6 percent in Asia (Maury 1997). The survey indicates that French engineering institutions (Grandes Ecoles), compared to other European universities, are more open to internationalization, have a more flexible curriculum to integrate periods of study abroad, and enjoy a higher level of autonomy (Maury 1997).

In general, European initiatives to foster student mobility in engineering can be divided into three types: (1) Pan-European joint degree, double degree, and certificate programs such as the Euronational Certificate (ENC) Program, (2) Government supported European Community initiatives such as ERASMUS/SOCRATES, and (3) Consortia of higher education institutions in the

U.S. and Europe that facilitate student exchanges among the member institutions (Humily 1997). The first two types are intended to enhance the European dimension and the third type addresses the international dimension between Europe and nations outside of Europe. Holmes (1997) suggested that programs like ERASMUS/SOCRATES have been successful in reaching their objectives of increasing student mobility within Europe, but there is a need to broaden it to wider international participation. Van der Gen (1997) offered two suggestions to achieve wider international participation by European students: (1) extend the European Credit Transfer System (ECTS) to a Global Credit Transfer System (GCTS) and (2) emphasize English language education in non-English language countries, since the language of science and engineering is English.

The ERASMUS/SOCRATES Program (described in detail in Chapter 4) has had the greatest impact on student mobility in Europe in all academic disciplines, including engineering (Giot et al. 1995; Giot and Grosjean 1995). This program has been successful in removing several barriers to study abroad due to: (1) significant interest in the program by engineering academic staff, (2) students' interest in gaining foreign language skills, self-development, academic learning experience abroad, and enhancing understanding of the host country (Giot et al. 1995), (3) financial support to higher education institutions to establish Inter-university Cooperation Programs (ICP's), (4) mobility grants for

students to assist with the extra costs of study abroad, and (5) the ECTS which standardizes credit transfer across the E.U. (van der Gen 1997). There are other E.U. initiatives designed to foster student mobility (also discussed in Chapter 4); however, ERASMUS/SOCRATES is currently, in 1998, the most comprehensive program and has been implemented longer than any other program -- since 1987 (van der Gen 1997).

CHAPTER 3

METHODOLOGY

This chapter describes the conceptual framework of this study, the methods used to select the population sampled and the sampling procedure. In addition, it outlines the questions answered by this study, the investigative categories, methods of data collection, and the evaluation and analysis of the data.

Conceptual Framework

In the literature on the topic of internationalization of higher education, authors have documented that an international dimension in the higher education curriculum and international experience is of tremendous personal, academic, and professional benefit to students in all majors, including engineering (see Chapter II). This study contributes to the general body of knowledge relative to the internationalization of higher education by investigating the barriers to study abroad experienced by engineering students and international program designs that intend to address these barriers.

Until recently, in the U.S. study abroad was regarded as an experience that was reserved only for well-to-do undergraduates at liberal arts colleges. Over the past 25 years, international experience as part of an undergraduate degree has gained importance at public universities and has been made more accessible to the typical public university undergraduate student. Therefore, American engineering students have access to international experience in theory, but not in practice. The results of this study assist university staff and faculty interested in developing international programs for engineering students to create programs and implement changes in the curriculum that will enable more engineering students to gain international experience.

Population Description and Sampling Procedure

The population of this study included all directors or coordinators of international programs for engineering undergraduates in the United States and Europe. The sample of this study included those directors or coordinators who were located by the researcher and whose input was solicited. These directors or coordinators were affiliated with an international office, a study abroad office, or a specific engineering department or college at a university. Some coordinators surveyed were faculty members who have created study abroad opportunities for their students. The sample included individuals at a variety of

institutions: public and private universities and colleges, including technological institutions. The sample consisted of 40 individuals in the U.S. and 69 in Europe.

Each director or coordinator surveyed oversaw at least one international program designed specifically for engineering students or a study/intern abroad program in which a significant number of engineering students participate (participating engineering students constitute an average of 2 percent of all students who study abroad at the institution). These international programs involved either a bilateral direct-exchange agreement between overseas universities or they were part of a consortium of overseas universities or they were internship arrangements with overseas internship sites such as engineering firms. There were a few exceptions to these three types of programs that are described in Chapter IV.

The sample for this study was obtained by searching the Internet, the Educational Resources Information Center (ERIC) database, and individual journals of higher education and international education for information regarding the presence and location of international exchange programs for engineering students in the U.S. and Europe. E-mail messages were sent asking for information from international programs offices at universities that offer engineering programs. Professional engineering organizations, the Accreditation Board for Engineering and Technology (ABET), the Conference of

European Schools for Advanced Engineering Education and Research (CESAER), and international education staff at technological universities and colleges were contacted regarding information concerning international programs for engineering students. Additional individuals surveyed were located through personal contacts in the United States and Europe. E-mail or telephone communication was established with program directors/coordinators and general program information such as brochures, catalogs, and other materials were requested from each program to determine basic program design.

Sources of Evidence and Authority

Questions Answered

(1) Have international exchange programs for engineering undergraduates in the United States and Europe removed barriers to study abroad as perceived by the directors/coordinators of these programs? The barriers include: (1) problems involving credit transfer of courses completed overseas (2) lack of support and encouragement to study abroad by engineering faculty and administrators, (3) lack of emphasis on foreign language and global awareness courses in engineering education, (4) stringent curricular design, sequencing, and requirements reflecting

accreditation standards, (5) lack of funding to develop programs and/or promote engineering student participation, and (6) students' misconceptions of study abroad.

(2) How have successful American and European international exchange programs for engineering undergraduates removed barriers preventing students from studying abroad?

(3) What factors are essential in the design of successful American and European international engineering programs as perceived by the directors/coordinators of these programs?

(4) How do European and U.S. programs compare with respect to program design and removal of barriers?

(5) What are the recommendations of program directors/coordinators for the design of international programs for engineering undergraduates?

Investigative Categories

The investigative categories included the variables used in the statistical analyses. In this study, the variables included: (1) promotional strategy (Item 4 on survey), (2) program design factors (Item 5 on survey), (3) barriers to study abroad (Item 6 on survey), (4) engineering curriculum rating (Item 9 A on survey), and (5) specific engineering program factors (Item 9B on survey).

Another investigative category was the survey respondents' perception of success of each program. Respondents had the following choices: (1) highly successful, (2) moderately successful, (3) developing, and (4) not successful. In addition, location of the institution (U.S. or Europe) was an investigative category in this study.

Methods of Data Collection

This study was descriptive in design and involved collecting data through utilization of a questionnaire from the sample, directors/coordinators of international programs that enable engineering undergraduate students in the U.S. and Europe to study abroad. The survey instrument was designed according to Dillman's Total Design Method (Dillman 1978). The survey packet included the questionnaire with directions, a cover letter, and an addressed, stamped return envelope. Sample copies of the questionnaire and cover letter can be found in the Appendix. The cover letter explained the purpose of the study, specific terms used in the questionnaire, and how responses will be evaluated and reported. The letters were printed on the letterhead of the Office of International Programs at Montana State University and were co-signed by the researcher and Dr. Norman Peterson, Director. Two weeks after the surveys were mailed, a follow-up postcard was sent to the sample group of this study, reminding them to complete and return the questionnaire. A sample copy of the

postcard can be found in the Appendix.

Content validity of the questions in the survey instrument were determined by three experts in the field of international education who are knowledgeable in the subject of study abroad opportunities for engineering majors: Dr. Norman Peterson, Director of International Programs at Montana State University, Dr. Burkart Holzner, Director, University Center for International Studies at the University of Pittsburgh, and Shaun Martin, Manager, Global Engineering Education Exchange Program, Institute of International Education, New York.

Reliability of the survey instrument was determined by a test-retest. One month after the surveys had been mailed to the entire sample group, pages 1 to 4 of the questionnaire were faxed to ten of the respondents. These respondents were asked to again complete items 1 to 7 for only one of the international programs they administer. Responses to items for this one program were compared to responses from the first questionnaire returned by the respondent to determine reliability of the survey instrument. Three reliability surveys were returned and all answers of these surveys matched the answers of the original surveys on all items tested.

Evaluation and Analysis

Items 4 to 9 of the questionnaire were analyzed through a chi-square test of independence. The chi-square test was used to determine whether program

success, as perceived by the respondents, is dependent on the investigative categories: (1) promotional strategy (Item 4 on survey), (2) program design factors (Item 5 on survey), (3) barriers to study abroad (Item 6 on survey), (4) engineering curriculum rating (Item 9 A on survey), and (5) specific engineering program factors (Item 9B on survey). A small number of programs did not fit the criteria of the survey instrument and were described as reported by the respondents. The survey results of all items in the questionnaire were described according to the following:

(1) Across and within institutions, what do programs that are rated as "highly successful," "moderately successful," "developing," and "not successful" by the administrator of each program have in common?

(2) What factors do the program designs of "highly successful" programs include?

(3) How and to what extent have "successful" programs removed barriers to study abroad?

(4) How do European and U.S. programs compare with respect to program design and removal of barriers?

(5) Based on the above information, what are the recommendations for a design of an international exchange program for engineering undergraduates in the United States that would maximize student participation in study abroad?

In addition, successful programs in the U.S. and Europe were described in a narrative manner.

Limitations and Delimitations

A limitation of this study was that only the responses of directors/coordinators of international exchange programs in engineering who volunteered to complete a questionnaire could be included in the analysis. A delimitation (a limitation imposed by the researcher) of this study was that program success was based solely on the perceptions or ratings of the directors/coordinators of these programs.

CHAPTER 4

FINDINGS

This chapter describes the results of this study, including descriptions of international programs for engineering students in the U.S. and Europe and analyses of the chi-square tests. The program descriptions were obtained through research on the Internet, from brochures and other information mailed to the researcher by program directors/coordinators, and from e-mail and telephone communication with program directors/coordinators. Table 1 shows the numbers of surveys mailed to program directors/coordinators in the U.S. and Europe and the numbers of surveys that were returned.

Table 1: Numbers of Surveys Mailed and Returned

Location	No. of Surveys Mailed	No. of Surveys Returned
U.S.	40	23
Europe	69	25

Of the 40 program directors/coordinators in the U.S., 23 responded to the survey and of the 69 in Europe, 25 completed the survey.

Descriptions of Programs

This study intended to identify specific program design factors that may contribute to the elimination of barriers to study abroad experienced by engineering students. The statistical analyses utilized in this study provide a partial understanding of the relationship between program design factors and program success. In addition, a description of the program designs of the international programs surveyed in this study is necessary to understand features of these programs that could not be analyzed statistically. Programs are described under the following headings: (1) Consortium-based programs, (2) Bilateral Exchanges, and (3) Institutional Programs. Consortium-based programs involve a consortium of overseas universities that offer exchanges to their students among the member institutions. Bilateral exchanges are designed for reciprocal numbers of students to be exchanged between two universities who have established an agreement to do so for a certain length of time. Institutional programs are special curricula, projects, and degree programs designed for engineering students at U.S. institutions to gain international experience as part of their engineering degree.

Consortium-Based Programs

1. Global Engineering Education Exchange (GE3) or American-European Engineering Education Exchange (AE3):

Global E3 is a program established in 1993 by a consortium of universities in the U.S. and western Europe. It also includes several selected institutions in eastern Europe, Asia, and Central America. In Europe the program is known as AE3 and in the U.S. it is known as GE3. In the U.S. it is administered by the Institute of International Education (IIE). This program facilitates the international exchange of engineering students among member institutions. Although Global E3 was established in 1993, not all of the institutions that are part of the program today were members from the beginning. Universities throughout the world are gradually added to the consortium to broaden the diversity of the participating student pool. Start-up funds for this program were provided by the National Science Foundation (NSF), AT&T Foundation, and the U.S. Department of Education. Long-term, the program is funded by membership fees from member institutions and private industry.

Participating students receive academic credit for courses taken at overseas member institutions as well as practical training for a summer, semester, or academic year. The students are nominated by their home institution to study abroad at an overseas member institution for a semester or an academic year, usually in their junior year. Global E3 provides intensive language instruction and practical, paid internships in industry or a laboratory in the host country. GE3 member institutions offer

almost all engineering disciplines, but not every discipline is available at every university. Students are matched with the institutions that offer the most appropriate academic program that corresponds to their curriculum at home.

There are 18 Global E3 member institutions in the U.S. and 33 in Europe. Many of these institutions have been members of Global E3 for three years or less making it difficult to determine whether the program is successful. Generally, there is an imbalance of reciprocal student numbers between the U.S. and Europe. Fewer American students than European students participate in the program, because there are fewer American member institutions than European ones.

Surveys were mailed to all 51 institutions in the U.S. and Europe to the individual listed as principal contact person on the IIE-Global E3 web page. Of the 18 American contact persons, nine returned the survey. Four of the respondents rated the Global E3 program as "successful" and three as "developing." Only one of these universities has been a member of Global E3 since 1993; the others joined in 1994, 1995, and 1997.

One of these universities has an average of 10 participating students per year and 10 participating students in the 97/98 academic year. The other institutions have an average of 1 to 3 participating students per year and the same number for the 97/98 academic year.

Of the 33 European institutional members of Global E3, ten principal contact persons completed the survey. All ten perceive the program as "successful" or "developing." One of these universities has been a member of Global E3 since 1993 and the remainder since 1995 and 1996, except for one that just became a member this year (1998). An average of 1 to 4 engineering students participate from each of the institutions per year as well as during the 97/98 academic year.

2. Atlantic Mobility for Academic Studies in Engineering and Environment (ATLAS) -- American and European institutions

ATLAS is a consortium of five European and five American research-based engineering institutions that intends to increase the cooperation between European and U.S. universities in the fields of engineering and environment. It involves an international student exchange program and a virtual learning environment. ATLAS is funded by the European Commission for a duration of three years: from September 1996 to July 1999. The program is coordinated by one university in Europe and one in the U.S.

The academic disciplines in the ATLAS program include environmental management and environmental engineering as applied to processing, civil, and mechanical engineering industries. ATLAS program

objectives include:

(1) Virtual mobility through the use of open and distance learning courses and new technologies

(2) Trans-Atlantic student exchange

(3) Targeted student packages

(4) Development of credit transfer systems

Students targeted by ATLAS are enrolled at the partner institutions as undergraduates or Master's degree candidates. They can participate in the program as exchange students and as virtual learners in distance education courses. At least two years of university studies are required before students may apply to ATLAS.

Exchange students participating in ATLAS may spend a semester or an academic year overseas. The minimum stay is three months. Students receive a travel grant and a tuition waiver for the study abroad time period. All course credits completed overseas that are relevant to the ATLAS program are transferred to the home institution. Every year ten students from the U.S. partner universities and ten from European partner universities are selected to participate.

Surveys were mailed to the five U.S. and the five European partner institutions. Three were returned from the U.S. and three from the European universities. Two of the American respondents perceive

ATLAS as successful with one of them also indicating that it is a "developing" program since it has been in effect for only two years. One perceives the program as developing only. Only one of the three European respondents included ATLAS in their completed survey. This respondent perceives ATLAS as successful.

The number of students participating in ATLAS during the 1997/98 academic year is 3, 10, and 0 at the three American institutions. The European institution has 2 participants for the same year.

3. Alliance for North American Mobility for Studies in Environmental & Mining Engineering (APEX) -- American, Canadian, and Mexican universities

APEX is a student exchange project funded by the U.S. Department of Education and its counterparts in Canada and Mexico for two years, from 1997 to 1999. There are six APEX partner institutions, two in each country, who exchange students on a reciprocal basis. The goal of the project is to enhance the education and practical experience of students who have an interest in the alleviation of environmental problems associated with the mining industry. Participation in APEX provides students with an international perspective on environmental, economic, and legal issues confronting the mining industry throughout the world.

APEX participants are undergraduate students who have completed at least two years of university course work and graduate students majoring in mining or environmental engineering and related fields of study. Graduate applicants must be in good academic standing and undergraduate must have a GPA of at least 2.5. Participating students from the U.S. must be U.S. citizens or permanent residents. Students can study abroad for one semester or a full academic year. The project encourages participation for a full academic year and applicants who agree to study abroad for the year are given preference.

Students who desire to study abroad at the Mexican universities must learn Spanish prior to leaving their home institution. Both American partner universities offer beginning Spanish courses and APEX provides tapes and tutors for intermediate and advanced Spanish conversation. Students going to the Canadian partner university in Quebec need some knowledge of French for participating in off-campus activities, but many courses there are taught in English.

Students pay the full tuition and fees of their home institution for studying abroad through APEX. The APEX project provides grants to participating students to cover living and travel expenses as well as other expenses related to APEX activities. The grants range from $1,500 to $3,000 per participant and are based on program length and expenses

rather than financial need. Other financial aid can be used for participation in APEX.

A survey was mailed to each of the contact persons listed on the APEX web page for the two U.S. partner institutions and only one of them completed the survey. The coordinator of the program at this university perceives APEX to be successful. Five students are participating during the 97/98 academic year.

4. Innovative Multi Cultural Curricula (IMCC) -- American and E.U. institutions

IMCC is a U.S./E.U. consortium of universities that was established in 1996 through funding by the European Commission, the US Department of Education, and the National Science Foundation. It is a joint 3-year educational and professional project which is designed to better prepare students in engineering and science for jobs and careers with universities and international companies. The consortium is comprised of three universities in the U.S. and eight in the E.U.

The project facilitates international student exchange and practical experience as part of study abroad. IMCC is open to undergraduate students with a minimum of two years of university education as well as graduate students who are either M.S. or Ph.D. candidates. Students

must have foreign language skills prior to participating in IMCC. Program participants may study abroad for a semester or an academic year. Several study options are available, such as taking courses, conducting research or participating in internships. Students pay tuition and fees at their home institutions for the semester or year abroad and receive a grant that covers travel, living expenses, and industry stipends.

The objectives of the program include:

- cross-cultural communication
- study abroad opportunities for degree credit at the home institution (undergraduate and graduate)
- industrial internships for graduate students as part of the curriculum
- research opportunities for graduate students
- faculty collaboration and exchanges (research, teaching, seminars, short courses)
- double degree recognition (future objective)

Two of the American IMCC coordinators responded to the survey, but one of them did not include the program in their survey responses. Only one of the E.U. member coordinators completed the survey. Both, the American and the European respondent, think of IMCC as a successful and a developing program. At the American institution an average of three students have been participating in IMCC and one

student is participating during the 1997/98 academic year. At the European institution these numbers are two students for each.

5. North American Regional Academic Mobility Program (RAMP) -- U.S., Canadian, and Mexican universities

RAMP is a consortium of Canadian, Mexican, and U.S. universities whose goal is to facilitate academic and professional mobility in engineering, business, and environmental studies. The program was established in response to the North American Free Trade Agreement (NAFTA) which does not only affect the trade of goods, but also the trade of professional services. RAMP assists in preparing individuals for professional mobility throughout the NAFTA region. It also assists employers who wish to serve clients in this region.

Currently, the consortium includes 48 institutions: 18 in Canada, 16 in Mexico, and 14 in the U.S. RAMP was implemented in 1992 under a grant from the U.S. Department of Education's Fund for the Improvement of Postsecondary Education (FIPSE), with cost-sharing by the Institute of International Education (IIE) and member institutions. Student exchanges began in engineering in 1993/94. The consortium is coordinated by IIE.

The RAMP consortium uses the format of the European Community Course Credit Scheme (ECTS) to transfer credits between

member institutions. ECTS is a standardized system for credit evaluation, recognition, and transfer between universities that have unequal course credit structures. The RAMP consortium collaborates with the Accreditation Board for Engineering and Technology (ABET) with regard to courses accepted for credit across national borders.

Students at all member institutions are eligible to participate in RAMP. In the U.S. most participating students are in their third undergraduate year. Each participating university determines its own criteria for accepting students to study abroad through RAMP. The program is based on a "tuition swap" system, so students pay tuition at their home institutions in the same amount as studying there. Students have to pay their own airfare, room and board, and health insurance. As part of the application process, students must demonstrate fluency in the language of instruction at the host university.

According to IIE, 270 students have participated in RAMP since 1993/94. U.S. students make up the smallest proportion of RAMP participants. Most of these students are from Mexico studying abroad in the U.S. or Canada. Over 50 percent of the students are in engineering, in part because the exchange in this field began five years ago (the business and environmental science exchanges began one and two years later, respectively). The largest number of study abroad placements have

been at Canadian institutions, followed by U.S. and Mexican universities.

Of the 14 U.S. RAMP member institutions, 6 offer exchanges in engineering. Four of these were mailed surveys and two were returned. The two institutions have been members of RAMP since 1992 and 1993. One respondent indicated that an average of 10 students participate in RAMP per year and that 10 students are participating during 1997/98. The other respondent indicated that only one engineering student has ever participated in RAMP. The respondent who indicated that 10 students participate each year considers RAMP to be "highly successful" and the other respondent considers the program "not successful."

6. SOCRATES/ERASMUS -- E.U. universities

The European Community Action Scheme for the Mobility of University Students (ERASMUS) was established in 1987 with the purpose of promoting the mobility and exchange of E.U. university faculty, administrators, and students. In 1995, in a slightly modified format, ERASMUS became the higher education section under the overall European Community Action Program in the field of education called "SOCRATES." The primary objective of ERASMUS is to educate university students in a European context as opposed to a single-country, -culture, and -language context. As the E.U. constitutes an effort to break

down national boundaries in Europe, ERASMUS is designed to remove national boundaries in higher education.

ERASMUS provides three different types of support to higher education institutions:

- grants to universities for European dimension activities
- mobility grants for students
- support to facilitate the activities of European associations of university teachers, administrative staff, and other awareness-raising activities

The grants to universities are awarded to institutions who implement policy changes to accommodate European dimension activities. These policy changes may include:

- developing ideal conditions for students to study at partner institutions in other E.U. countries
- introducing the European Credit Transfer System (ECTS)
- exchange opportunities for faculty members
- curriculum development activities

and other activities designed to infuse a European dimension into all university functions.

The mobility grants for students constitute direct financial aid to students studying in another participating country for a time period of 3

months to a full academic year. The financial aid is meant to be used for additional costs associated with studying in a foreign country, such as travel, differences in cost of living, language classes, etc.

In 1987, when ERASMUS was established, there were 12 member nations in the EU who were part of the ERASMUS program. In 1997, ERASMUS included 18 countries (the 15 EU countries and Norway, Iceland, and Liechtenstein). In 1998, ERASMUS will be open to participation by Hungary, Romania, the Czech Republic, and Cyprus. Since 1987/88, approximately 500,000 students have studied abroad under the ERASMUS program (these are students in all fields of study).

The European Credit Transfer System (ECTS), used by universities participating in ERASMUS, is designed to assist in facilitating the objectives of ERASMUS. It is a standardized system of academic credit allocation and transfer between E.U. universities. The ECTS enables students who study abroad to earn credits relevant to their degree and it ensures full academic recognition of credits earned abroad. If the ECTS accomplishes what it is intended to do, it would effectively eliminate one of the barriers to study abroad experienced by university students in all majors.

Of the 24 European directors/coordinators of international programs for engineering students who returned the survey, 16 indicated

that their institution is an ERASMUS partner and that a significant number of engineering students at their university study abroad through the program. All of these respondents perceive ERASMUS as either "highly successful" or "moderately successful" at their institution.

7. LEONARDO DA VINCI and other E.U. consortium programs

LEONARDO DA VINCI is a practical internship program for students in technology disciplines that is similar in design to ERASMUS. It allows E.U. students in engineering and science to intern in private industry in any E.U. country as well as Norway, Iceland, and Liechtenstein. Students receive a monthly stipend, a travel allowance, and financial aid for language training, if needed. It is recommended that students already have a basic knowledge of the internship site's language. The time period for the internship is three months to one year. Four of the survey respondents included LEONARDO and all indicated that the program is successful at their institutions.

A number of other study/intern abroad programs have been developed among E.U. member nations. Some of these are part of the ERASMUS program and some were developed using ERASMUS as a model. Most of these programs are open to students in all majors and a few are specifically designed for technology majors. The programs that

were included by survey respondents are:

8. Euronational Certificate for Engineers and Technologists (ENC)
9. Tempus
10. Cooperative Link between Universities of Science and Technology for Education and Research (CLUSTER)

Bilateral Exchanges

All of the institutions surveyed have established bilateral exchanges with overseas universities. A typical bilateral exchange is designed for reciprocal numbers of students to be exchanged between the two universities. These types of exchanges may be open to students in all majors offered at the host university or they may be open to specific majors only. Typically, students pay tuition and fees at the home institution to study abroad, which allows resident students in U.S. states to pay in-state tuition while studying at overseas universities. U.S. students may also apply federal financial aid to study abroad. Admission to the host university, credit transfer between the universities, and other administrative tasks are coordinated between staff at the two universities. The partnership agreement between the universities generally outlines articulation agreements and other institutional policies related to student exchange.

Institutional Programs

1. The Global Perspective Program at Worcester Polytechnic Institute (WPI)

WPI offers engineering students a unique curriculum that includes experience-based projects that can be completed at overseas project centers established by WPI. The Sufficiency Project, usually completed in the sophomore year, is designed to give students a deep understanding in an area outside of their major field. The Interactive Qualifying Project (IQP), typically completed by students in their junior year, requires students to conduct research involving the relationship between society and the advance of technology. The Major Qualifying Project (MQP) is a major research or design effort in a student's area of concentration. Typically completed in teams and on a topic of the students' choosing, this project is the culmination of a WPI undergraduate education.

The Global Perspective Program at WPI has established a number of exchange opportunities and project centers for engineering students to study abroad and complete a qualifying project. In theory, these opportunities allow students to complete a Sufficiency, IQP, MQP, and exchange program overseas. The qualifying projects can be completed at WPI, but a large percentage of WPI students choose to complete theirs while abroad. The Global Exchange Program offers study abroad opportunities of varying length at seven overseas technology universities in six countries. These are typical bilateral exchange

agreements that allow for a reciprocal exchange of students between WPI and the partner universities. Independent of these partner universities, off-campus project sites have been established in twelve countries (including the U.S.). The project sites offer a residential program where WPI students live, study, and complete projects as a group.

Projects completed at the project sites involve real-life, necessary research conducted in cooperation with local non-profits, government, and community agencies. For example, WPI students at the Venice project site have worked on projects sponsored by the city and private agencies. One project involved cataloguing the ornate, often neglected ancient flagpole pedestals found throughout Venice. Another involved developing a prototype plan to computerize the dispatching of ambulance boats, which risk getting trapped beneath low bridges at high tide. Students were also studying the feasibility of new vacuum-sewer technology, collecting data designed to improve canal maintenance, and determining how the city could reduce the traffic of cargo boats, whose wakes damage buildings.

WPI's academic year is divided into four seven-week terms. A full-time load is three courses per term for a total of 12 courses per year. The IQP and MQP are equivalent to three courses each. This allows students to devote a full seven-week term exclusively to each project. If the projects are completed at off-campus project sites, students can spend seven-week terms abroad without

having to worry about credit transfer issues or making up time spent abroad.

According to the Director of WPI's Interdisciplinary and Global Studies Division, the IQP and MQP options abroad at off-campus project centers are highly successful. During the 97/98 academic year, 150 WPI engineering students (10% of the total number of engineering students at WPI) studied abroad. Due to increased promotion this number will increase to 250 in 98/99. WPI's conventional bilateral exchanges in partnership with overseas universities are not successful. The majority of students at WPI who study abroad do so at off-campus project centers.

2. The International Engineering Program (IEP) at the University of Rhode Island (URI)

The IEP was established in 1987 through cooperation between engineering and German faculty at URI. The program is a five-year course of study leading to both a Bachelor of Science in one of the engineering fields and a Bachelor or Arts in German. The IEP includes specialized German language courses for engineers, a six-month paid internship with an engineering firm in Germany, a capstone senior-level engineering course taught in German by URI engineering faculty, and assistance with job placement in international companies. In 1997/98 approximately 100 undergraduates were enrolled in the German IEP, over 60 have completed the internship, and over 50 have

completed the program.

The program was originally funded with a U.S. Department of Education grant and now works with a number of global partner companies ready to help educate globally competent engineers. These companies have provided internships and have employed many of the IEP graduates. A number of these companies also contribute to the IEP Scholarship Fund on a regular basis.

Prior to or following the internship, IEP undergraduates have the option of studying abroad in Germany through an exchange program with the Technische Universität Braunschweig. This bilateral exchange was established in 1995 with support from the U.S. Department of Education and the van Meeteren Foundation in Germany. Students complete a semester of study for full credit at Braunschweig in addition to the six-month internship for a full 11 months in Germany. This amount of time studying and working in Germany provides undergraduates with strong skills in the German language and an outstanding background in German culture. It also helps students to become familiar with the German engineering firm environment. Since 1995, approximately ten students study abroad each year through this exchange.

URI engineering undergraduates who are not in the IEP may also participate in this exchange with Braunschweig; however, they must have completed German language courses through the sixth-semester level. There are several opportunities for students to learn German. Engineering faculty at

URI encourage undergraduates to take German as freshmen and sophomores. URI also offers an eight-credit summer course in German. In addition, Braunschweig offers an intensive German course for foreigners at the beginning of each semester.

The cost of studying abroad at Braunschweig is the same as studying at URI and the internships are paid. So students just have to pay for transportation which is often supported by gifts from the van Meeteren Foundation. In addition, students do not pay tuition during the internship semester in Germany. Therefore, since the IEP is a five-year program, students pay tuition for one extra semester as compared to the typical eight-semester engineering degree.

Due to the success of the German IEP, URI also developed the French IEP based on the same model in 1995. Approximately 30 students are working on a Bachelor of Arts in French along with their engineering degree in 1997/98. URI and T.U. Braunschweig also developed a dual degree program for masters degree students in 1997. This program allows graduate students to earn two degrees simultaneously: (1) the Masters of Science in Civil, Electrical, or Mechanical Engineering at URI and (2) the German Diplom in the same disciplines of engineering at Braunschweig.

3. The International Programs in Engineering (IPE) Office at the University of Illinois, Urbana-Champaign (UIUC)

The UIUC College of Engineering has established the IPE Office in cooperation with the UIUC Study Abroad Office to administer study abroad programs specifically designed for engineering majors. IPE offers summer, semester, and academic year study abroad opportunities, as well as an international minor. Students can choose from 11 overseas summer programs and five semester/academic year exchanges. The semester/academic year exchanges are with universities in Belgium, France, and Germany. UIUC is also a member of the Global E3 consortium (see "consortium-based programs" section above) offering exchanges with 35 European universities. In addition, engineering students can choose to study abroad through any of the vast number of exchange opportunities coordinated by the UIUC Study Abroad Office.

The UIUC College of Engineering offers an international minor in engineering as part of the regular engineering degree program. Undergraduates who choose this option are able to concentrate course work in the social sciences and humanities on a particular country or region. As part of the program, students also work or study abroad. To qualify for the international minor, students must complete foreign language study in the language of their chosen country or region. Students must spend at least six weeks in residence in that country or region and may apply a typical international exchange to this requirement.

The designated international minors for which curricula have been established at UIUC are: African, Chinese, French, Germanic, Japanese, Latin American and Caribbean, Middle Eastern, Slavic, South Asian, and Spanish Studies. IPE allows students to consider any non-English speaking country or geographical area for the international minor, but all programs have to be approved by the IPE Office and the Office of the Associate Dean for Academic Programs in the College of Engineering.

The summer programs offered through IPE are perceived as highly successful and other study abroad programs are perceived as moderately successful by the Director of IPE. In 1997/98, 110 students studied abroad (including summer programs) out of a total of 5,360 engineering students (2 percent of all engineering students).

4. The Engineering Program for International Careers (EPIC) at Clemson University

The EPIC Program at Clemson University is a five-year program for engineering undergraduates that includes an overseas internship and academic experience. Typically, students complete an internship with a foreign engineering firm in the fall semester of their fourth year. Following the internship, students have the option of staying overseas for an additional term to take courses at a university for credit toward their engineering degree. The

internship-sponsoring company provides a salary or stipend sufficient to cover all travel and living costs abroad and assists with finding suitable housing. EPIC was established in 1992 and has an average of 15 participants each year.

The program includes foreign language courses, including technology-oriented language immersion summer sessions. Students can choose from French, German, Japanese, and Spanish. A typical EPIC schedule involves two foreign language classes during the sophomore year, a third language class during spring semester of the junior year followed by the language immersion summer session before heading overseas in the fall of the senior year. After returning from interning and studying abroad, students take an upper division language course and an international social science elective. Altogether the program includes 20 credits in a specific foreign language. During the five years of the program, EPIC students complete all of the standard engineering course work required for a bachelor's degree in engineering as well as an industrial internship with a U.S. company during fall semester of their junior year.

5. Other

Several colleges of engineering at institutions in the U.S. have established "study abroad" or "international programs" offices that administer exchanges specifically designed for engineering students (see UIUC above). These offices usually work in cooperation with the university's study abroad programs office.

According to the administrators of these "college of engineering international programs offices," this type of arrangement is successful. Four of the survey respondents belonged to this group of administrators.

Statistical Analyses

In this study, a chi-square test of independence was conducted to determine whether the variables in the survey are related. A chi-square test compares observed and expected frequencies of events and determines whether a statistically significant relationship exists between variables. The data are arranged in a contingency table and the statistical test is made to determine whether classification on the row variable is independent of classification on the column variable. The null hypothesis signifies independence between the variables. For example, in this study, the chi-square test of the independent variable, institution location (U.S. or E.U.), and the dependent variable, elimination of one of the barriers to study abroad, yielded an expected and an observed frequency of "Yes" and "No" responses for each of the two locations. If there was a statistically significant difference between the observed frequencies for each location, then there is a relationship between location and elimination of the barrier and the null hypothesis is rejected. The observed and expected frequencies for "Yes" answers indicate the direction of the relationship, meaning

whether the elimination of the barrier in question is more strongly associated with U.S. or E.U. programs.

Chi-square tests of independence were used to determine whether program success, as perceived by the directors/coordinators of each program, was dependent on the following variables: (1) promotional strategy (Item 4 on survey), (2) program design factors (Item 5 on survey), (3) barriers to study abroad (Item 6 on survey), (4) engineering curriculum rating (Item 9 A on survey), and (5) specific engineering program factors (Item 9B on survey). A chi-square test of independence was also used to determine whether the same variables are dependent on the program being administered in the U.S. or in Europe (location of the institution). Finally, program success was cross-tabulated with location (U.S. or Europe) to determine whether success is dependent on location.

Tables 2 to 11 show the results of the chi-square analysis. The chi-square values and p-values are indicated for each cross-tabulation. The chi-square value depends on the disparity between the observed frequencies and the expected frequencies, with the value becoming larger as the disparity increases. The p-value indicates the probability of obtaining, by chance, sample frequencies that deviate as much or more from the calculated expected frequencies as the observed frequencies. The greater the disparity between the expected and the observed frequencies of Yes/No answers, the smaller the