AC 2012-3195: EDUCATING ENGINEERING STUDENTS TO SUCCEED IN A GLOBAL WORKPLACE

Dr. Vukica Jovanovic, Trine University

Vukica Jovanovic, Ph.D., began her academic career in 2001 when she graduated with her dipl.ing.-M.S. degree at University of Novi Sad, majoring in industrial engineering and focusing on mechatronics, robotics, and automation. She lectured various courses at departments of Industrial Engineering, Mechanical Engineering, and Mechatronics from 2001 until 2006. She was an active member of a European organizing committee of the student robotic contest Eurobot and chief of the Eurobot organizing committee of the Serbian student national competition in robotics. In the summer of 2002, she had an internship in aircraft manufacturing company Aernnova Aerospace, Spain, where she worked in assembly of aircraft wings. Jovanovic subsequently continued to work towards her doctorate at Purdue University, Department of Mechanical Engineering Technology in Aug. 2006, as a Graduate Research Assistant in Product Lifecycle Management Centre of Excellence Laboratory. As a graduate student, she was involved in the following projects: Boeing PLM Certificate Program, Society of Manufacturing Engineers Education Foundation Project: Product Lifecycle Management Curriculum Modules, National Science Foundation project: Midwest Coalition for Comprehensive Design Education, and Department of Labor-funded project: Development of Integrated Digital Manufacturing Curriculum. She was also lecturing six different courses in the areas of mechanical engineering technology and computer graphics technology. She published chapters in three books, three journal articles, and presented 31 conference papers. Her dissertation research focused on environmental compliance, product lifecycle management, and engineering design of mechatronic products. She is working at the Design Engineering Technology Department at Trine University, where she teaches courses related to engineering graphics and design.

Prof. Thomas H. DeAgostino, Trine University

After graduating from Michigan Technological University with a B.S. in mechanical engineering in 1984, Thomas H. DeAgostino began his career as an Automotive Product Engineer working at Ford Motor Company's Heavy Truck Division. He held various product engineering positions before settling on structural and finite element analysis as his engineering passion. In 1988, he transferred to Ford's Engine Engineering Division, performing finite element analysis on various engine components. In 1991, he left Ford Motor Company's Engine Division for General Motors' newly forming Powertrain Division, to work on automatic transmission torque converters. While at GM, he obtained his M.S. in engineering science from Rensselaer Polytechnic Institute in 1995. After holding various positions in product engineering at GM, he turned to teaching mathematics at Jackson (Mich.) Community College in 2007, and finally accepted his current position at Trine University in 2009 as Assistant Professor of design engineering technology. He currently teaches statics, mechanics of materials, machine design, and the senior design capstone sequence. His research interests include integration of industry and academia and utilization of project-based learning to enhance the applicability of learning.

Dr. M. Brian Thomas P.E., Trine University
Prof. R. Thomas Trusty II, Trine University

Educating Engineering Students to Succeed in a Global Workplace

Abstract

Current and future graduates from engineering and technology programs will need certain skills in order to work effectively in a global environment. Most engineers, at some point in their careers, will work with colleagues in foreign countries, either as co-workers, customers, or suppliers. Study-abroad programs are a powerful tool for training students in cross-cultural communication. While many study-abroad programs exist, few engineering students participate, largely because these programs are disruptive to a student's plan of study. This paper reviews the development of a study-abroad program specifically for engineering and technology students. The proposed program will have participants studying in their disciplines at a host institution in a non-English speaking country. Participants will also tour engineering facilities and attend cultural events. This for-credit program will enhance the cultural intelligence of participating students, giving them a competitive advantage for starting their careers in the global marketplace.

Introduction

The engineering field is quite different in the twenty-first century than it was previously. Being an engineer has become much more than being a good problem-solver, critical thinker, and independent thinker. It also requires interpersonal professional skills (the so-called "soft skills"). New developments in information technologies and more accessible transportation, along with offshoring and global design efforts, have lead to these changes. Engineering graduates need to understand the importance of interpersonal professional skills for their career advancement in today's global, open market economy[1,2]. Moreover, since modern engineering work is very often collaborative in nature, there is a need for courses in the curriculum to develop these skills in engineering students. Part of this need is addressed by required social studies and humanities courses that focus in some way on a global perspective. However, there are not many study-abroad programs and exchange programs that focus on experiences specifically tailored for engineering and technology occupations.

The advance of information technology has led to an increasing number of nations joining the world marketplace. This diverse and complex global environment requires businesses to engage in adaptive strategies in order to remain competitive[3]. Having global competency has become an essential skill for workers – particularly for engineers who work in multinational companies. Positions offered to recent engineering graduates will often include temporary assignments at international facilities. Cultural sensitivity is becoming a necessary skill, especially in the current competitive job market.

Planning for a Study Abroad Course for Engineering and Technology Students

Developing a short-term study abroad program usually takes about a year and a half. The development process for a study abroad program is shown in Figure 1.

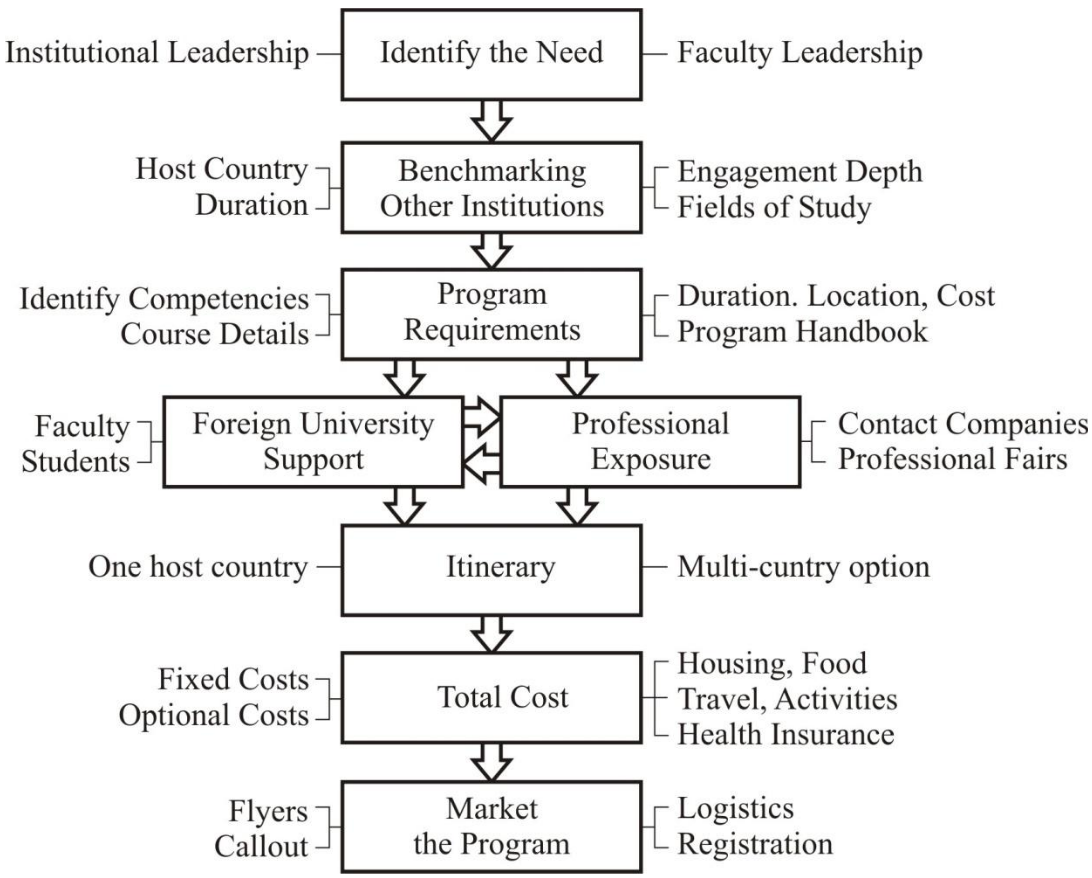

Figure 1: Study abroad program development

The development of the study abroad program starts with benchmarking programs at similar institutions. The process then defines the program's requirements and content (cost, location, and duration), foreign university support, professional exposure through trips to companies and professional fairs, and how to attract students to enroll in the program. All these phases have the goal of providing the best fit for the student body at the home institution. Development of a study abroad program might start from institutional initiative (top down approach) or as a proposal from faculty who would be involved in it (the bottom up approach). The first step would be identification of need and assigning of faculty and institutional roles.

Global Competency and Cultural Sensitivity

According to many recruiting managers, major companies need global citizens who have global sensitivity, perspective, insight, and the capacity for taking risk[4]. Young professionals who understand the dynamics of a global economy and intercultural relations have an advantage in finding jobs with companies doing business in the global environment[5]. Even within the United States, companies will need a level of cultural sensitivity to reach the diversity of customers within their borders[6]. New engineers may work with colleagues from a culture other than their own. This can occur "virtually" at a distance, in person at an international site, or next door in the office of a multinational corporation. Engineering projects are distributed across different sites; successful collaboration needs professionals who can effectively work with coworkers who are very different from themselves[2]. In addition, cultural competence and foreign language skills can prove invaluable when working on global business teams or negotiating with overseas clients[6].

One measure of cultural sensitivity is the Global Leadership Competency (GLC) Model of cultural intelligence, shown in Figure 2. This model presents a hierarchy of competency factors and the developmental path of global awareness; from the deficiency stage of ignorance to an ideal high level of competence known as adaptability[7]. Cultural intelligence reflects a capability to gather and manipulate information, draw inferences, and enact behaviors in response to one's cultural setting. To be culturally adaptive, a core set of cultural competencies must be mastered. To achieve the adaptation level, skills that include cognition, motivation and behavior have to be developed[7]. Young professionals need to learn a variety of information about diverse cultures and their cultural customs (cognitive knowledge). These abilities are related to personal efficiency, persistence, goals, value system and integration (motivation). Another layer is related to the ability to interact in different situations, environments and diverse groups (behavioral adaptability).

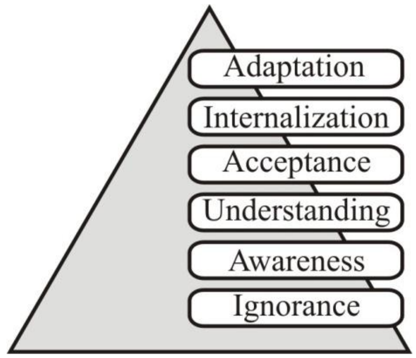

Figure 2: GLC Global Competency Model[7]

Another definition of global competence is, "having an open mind while actively seeking to understand cultural norms and expectations of others, and leveraging this gained knowledge to interact, communicate and work effectively outside one's environment"[8]. Yet another competency model made by the Association Internationale des Etudiants en Sciences Économiques et Commerciales (AIESEC) is given in Figure 3. By this definition, agents of positive change that are related to global competence are: entrepreneurial outlook; global mindset; social responsibility; emotional intelligence; and proactive learning[10].

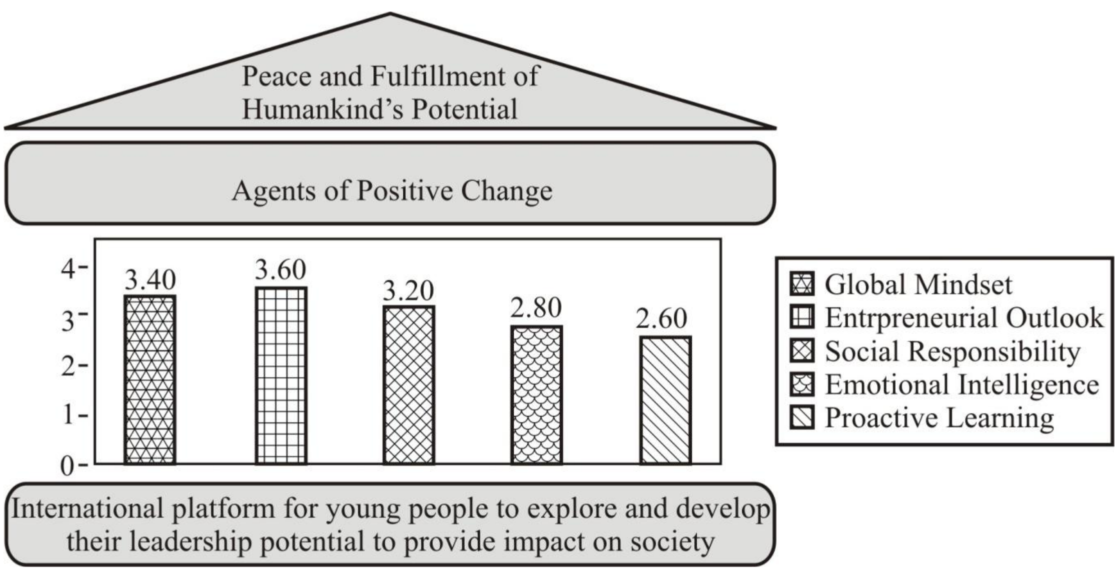

Figure 3: AIESEC Global Competency Model in 2011[10].

Global competence can also mean, “having an open mind while actively seeking to understand cultural norms and expectations of others, leveraging this gained knowledge to interact, communicate and work effectively outside one’s environment”[11]. However, global competency differs for people in various professions. It may not necessarily mean the same thing for foreign language teachers, church missionaries, military staff, or engineers[11].

Being internationally competent can mean obtaining many different attributes, as shown in Table 1[12]. Some skills are related to cross cultural relationship skills, some are related to personal traits and values, and others are related to cognitive orientation.

Table 1: International competences[12]

Cross cultural relationship skills	Traits and values	Cognitive orientation
Building relationships	Inquisitiveness and curiosity	Environmental scanning
Cross-cultural communication skills	Continual learner	Global mindset
Ability to emotionally connect	Accountability	Thinking agility
Inspire, motivate others	Integrity	Improvisation
Conflict management	Courage	Pattern recognition
Negotiation expertise	Commitment	Cognitive complexity
Empowering others	Hardiness	Cosmopolitanism
Cross-cultural ethical issues	Maturity	Managing uncertainty
Social literacy	Results-orientation	Local vs. global paradoxes
Cultural literacy	Personal literacy	Behavioral flexibility
	Tenacity	
	Emotional intelligence	

It is very challenging to create curriculum materials that implement objectives related to all these attributes. Some attributes are related to personal skills that the university experience surely brings to students, but those related to cross-cultural relationships are challenging to develop solely within the on-campus environment. Examples of these hard-to-develop skills include managing cross-cultural communication skills, ethical issues, and behavioral flexibility.

Many U.S. schools require students to take courses having a global perspective. Not all states, though, have the same requirements. Engineering students can graduate with only a basic knowledge of the geography and culture of world regions. This problem is exacerbated in the United States, where most international travel requires extensive air travel due to the nation’s size and bordering oceans. In contrast, European students are much more likely to travel to other countries due to their proximity to international borders.

Study Abroad Programs at American Universities

A 1998 report published by the Council on International Education Exchange recommended three characteristics for American students in international programs: travel to regions where English is not the dominant language; program length of three months or more; and, above all, travel to countries not usually chosen as travel destinations by Americans[13]. Most study-abroad programs apparently do not meet these criteria.

The five most popular destinations for American students studying abroad are the United Kingdom, Italy, Spain, France, China, Australia, Germany, Mexico, Ireland and Costa Rica, as shown in the Table 2. Our study abroad program would be in the host country Republic of Serbia, with additional travel to Hungary, Austria, and Germany. Only Germany appears on the list of popular study-abroad destinations.

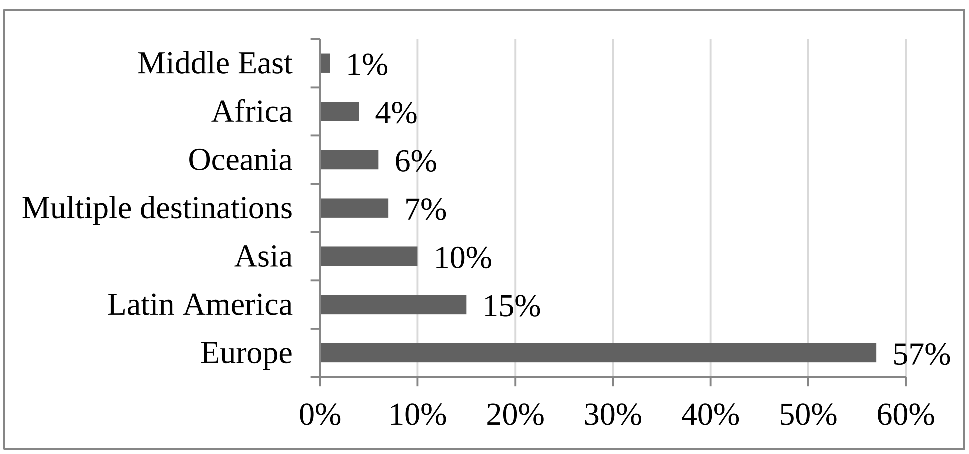

Figure 4: Percent of study abroad performed in various parts of the world, 2006-07[14].

In the 2006-7 academic year, there were 17.6 million undergraduate students in the U.S.[15, 16]. Of these, 241,791 students, or 1.4% of all students, studied abroad that year. 57% of these students travelled to Europe[14], as shown in Figure 4. Encouragingly, the plurality of participating students was enrolled either in summer-term (38.7%) or semester-long (36.3%) programs; another 4.9% were in two-quarter or year-long programs[14] (Table 3).

Table 2: Top 10 destinations of U.S. study abroad students, 2009/10[17]

Rank	Destination	2009/10	% of Total
1	United Kingdom	32,683	12.1
2	Italy	27,940	10.3
3	Spain	25,411	9.4
4	France	17,161	6.3
5	China	13,910	5.1
6	Australia	9,962	3.7
7	Germany	8,551	3.2
8	Mexico	7,157	2.6
9	Ireland	6,798	2.5
10	Costa Rica	6,262	2.3

Table 3: Duration of study of U.S. study abroad students, 2000/01 - 2009/10[17]

Duration of Study	Percent of U.S. Study abroad students (2009/10)
Summer Term	37.8
One Semester	35.8
8 Weeks or Less During Academic Year	11.9
January Term	6.9
Academic Year	3.8

Certain disciplines, including engineering, have historically had fewer students studying abroad. In 2009-10, only 3.9 % of the undergraduate students enrolled in study-abroad programs were engineering students, as shown in Table 4. By contrast, 22.3 % of students in the social sciences and 20.8 % of business and management undergraduates had studied abroad[17]. One reason for the low participation is the heavy class load that engineering students usually carry, making it harder for them to spend a semester away from their home institution [17]. Engineering students typically want to graduate as quickly as possible, and are more interested in short-term study abroad programs, lasting eight weeks or less, that will not disrupt a highly-structured, sequential curriculum. Therefore, there are more short-term programs available at American universities. Many 1- to 3-week programs allow faculty from the home university to travel with the students[18].

Table 4: Fields of study of U.S. study abroad students, 2000/01 - 2009/10[17]

Field of Study	Percent of U.S. Study abroad students (2009/10)
Social Sciences	22.3
Business & Management	20.8
Humanities	12.1
Fine or Applied Arts	8.3
Engineering	3.9

Benchmarking Study

Our institution is located in a rural community, and draws its students largely from a 100-mile radius encompassing Indiana, Ohio and Michigan. It is classified as an undergraduate university according to the Carnegie Classification. While students do have access to existing study-abroad programs, these programs do not specifically target engineering and technology students, nor do they accommodate faculty leadership or participation. The proposed program will have two main components: on-site study at a foreign institution, and visits to international companies. These elements will provide students with insight as to how engineers collaborate across borders, particularly when English is not the primary spoken language, and will allow them to interact with their peers and future colleagues at a foreign university.

The total number of study-abroad students enrolled through institutions in the state of Indiana in the 2009-10 academic year was 9,825. In Michigan, it was 8,982, and Ohio, 10,763 students[19]. In these three states, the top participating doctoral institutions (according to Carnegie Classification) in study-abroad programs, by the percentage of participating undergraduate students that got their degrees in 2009-10, were the University of Notre Dame (56.8 %) and Miami University of Ohio (40.7 %)[19]. Top participating master's institutions in the same year were the University of Evansville (48.6 %), Butler University (43.2 %), Valparaiso University (32.8 %), and Spring Arbor University (31.1%)[19]. Of these, only Butler and Spring Arbor do not have engineering programs. Undergraduate institutions with the highest participation are listed in Table 5. Significantly, the institutions in Table 5 are all identified as liberal arts schools.

Table 5: Top participating undergraduate institutions in Indiana, Michigan and Ohio[19]

Rank	Institution	State	Undergraduate Study Abroad Students	Total UG Degrees Conferred 2009-10	Estimated % UG Participation in Study Abroad
4	Earlham College	IN	207	212	97.6
7	Taylor University	IN	455	492	92.5
9	DePauw University	IN	432	491	88.0
10	Oberlin College	OH	559	644	86.8
12	Kalamazoo College	MI	253	304	83.2
15	Hanover College	IN	121	163	74.2
20	Saint Mary's College	IN	259	376	68.9
28	Calvin College	MI	597	908	65.7

From the listed schools, Valparaiso and Evansville are most like our institution. All are small private institutions with accredited engineering programs. The benchmark schools both have established semester-long study-abroad programs with partner institutions in Germany (Valparaiso) and the United Kingdom (Evansville). The curricula for these programs, though, are better-suited for a liberal arts degree. Only one course offering between the two, Calculus III, fits in an undergraduate engineering sequence.

Two of the main reasons for lower participation of engineering students in study abroad programs are the different humanities and social study requirements and tight engineering curriculum. In many foreign countries, engineering students take few classes in humanities or social sciences. For example, engineering students in the Republic of Serbia take only one humanities course (Sociology) through their whole four years of study. They also choose a foreign-language course in either English or German. However, these do not meet the transfer requirements for most U.S. institutions. In addition, some Serbian engineering courses, such as Materials or Engineering Graphics, have 4 hours of lecture and 4 hours of labs (8 total credit hours). The first-year Mechanical Engineering curriculum at the University of Novi Sad (Novi Sad, Serbia) is given in Table 6. Students take 26 hours of labs and lectures per semester with only one non-engineering language course.

Table 6: Required courses at the first year of Mechanical Engineering: Technical Mechanics and Engineering Design at University of Novi Sad[20]

Course	Semester	Course	Lectures (hours)	Labs (hours)	Total
1	1	Mathematics I (Algebra)	3	3	6
2	1	Mechanics I (Statics)	2	2	4
3	1	Basics of Programming	0	4	4
4	1	Materials	4	4	8
5	1	Physics or Chemistry	2	2	4
		Total number of hours per semester:	**11**	**15**	**26**
6	2	Mathematics II (Calculus)	3	3	6
7	2	Mechanics II (Kinematics)	2	2	4
8	2	Engineering Graphics	4	4	8
9	2	Electrical Machines and Electronics	3	3	6
10	2	English or German	2	0	2
		Total number of hours per semester:	**14**	**12**	**26**

Another problem related to a whole-year study abroad program is that the courses are taught in Serbian. U.S. students in a study-abroad program would presumably need time to learn the Serbian language. This is a significant challenge, as Serbian is presumably not offered at most U.S. institutions.

Proposed Study Abroad Solution

After the benchmarking study, faculty discussed the length of the proposed program with the department chairs, college dean, and the vice president of academic affairs. It was decided that a three-week program in May, following the spring semester, would be the best possible solution for our institution.

The next stage of this project required contacting foreign engineering institutions to find faculty and graduate students who would be willing to participate in this program. One factor that simplified this search was that one of the authors earned two degrees and had served on the faculty of the institution that was ultimately selected. After identifying a host institution and personnel, a multi-country itinerary was drafted. Two possible programs were developed: a one-country (Republic of Serbia) itinerary, and a multi-country option (Republic of Serbia, Hungary, Austria, and Germany, as shown in Figure 5). These adjoining countries offer a rich diversity of experience for participating students: East and West Europe; European Union and non-EU.

Significantly, all are non-English speaking countries. Having the draft itinerary allowed the planning team to establish costs for accommodations, food, travel, activities, and support personnel from the home institution.

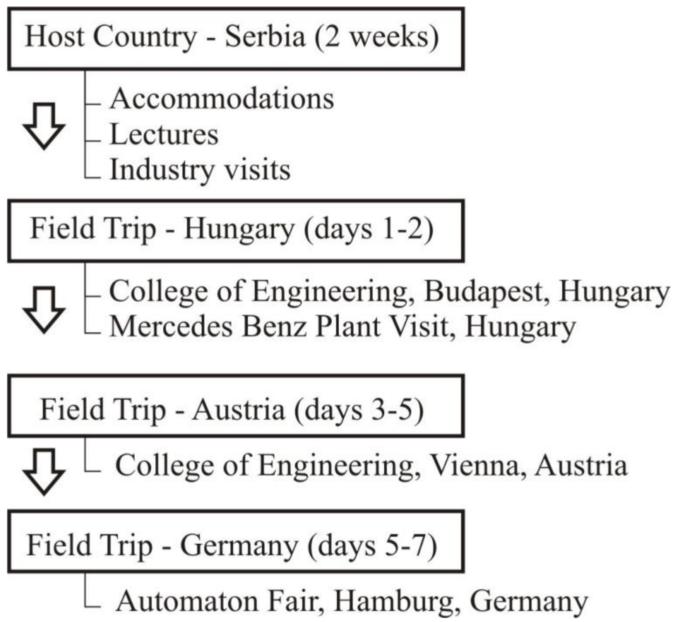

Figure 5: Proposed multicounty itinerary

Probably the best way for students to gain local experience would be taking a year of courses at a foreign institution. This approach is popular for students majoring in a foreign language, social sciences, or humanities. In this, they get immersed in a local culture and exposed to a foreign language much more that would be possible at their home institution.

The depth of engagement is related to the length of the study-abroad program, as shown in Figure 6. They are higher for longer programs in which students participate with the local student population. During shorter study-abroad programs, travelling with a faculty from their home institution (U.S. faculty), the depth of engagement is probably smaller. While shorter, these can be more intensive.

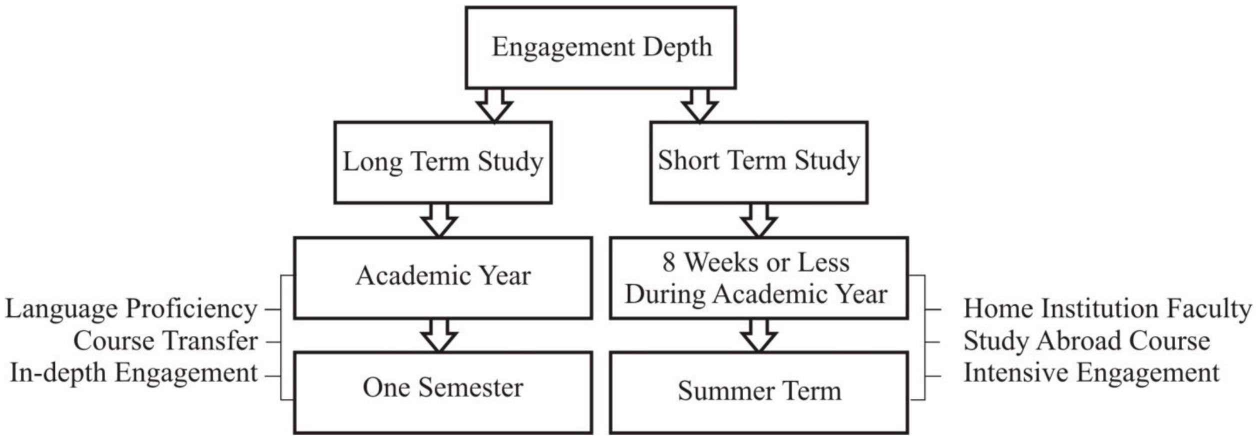

Figure 6: Level of engagement depth

This study abroad program is designed as a field-based learning experience, including excursions and industry site visits, talks and lectures by foreign engineering professors, formal and informal meetings with faculty, students, and others in host countries, and discussions with the instructor and other students in the individual courses. Students will attend lectures with other local students, taught in English by host-institution faculty. Local events and sightseeing will give students the opportunity to learn more about the host countries' culture, people, history, and industry. Participating students will earn three credit hours for this course. Gains in cultural competency will be measured with the Global Competence Aptitude Assessment, before and after the program[8].

The main focus of this study-abroad program is not language skills. It is about developing new skills in students through interaction with international engineering students in an international setting, visiting foreign companies, and interaction with faculty from a host institution. Therefore, students will communicate on English with their peers and host faculty. By travelling with Serbian engineering students and faculty to the other countries, they will be exposed to Serbian culture through the whole program.

Course Syllabus and Program Handbook

Depending of their area of study, the students will be involved in projects with local students in one of the following courses: Mechatronics; Home Automation; Programmable Logic Controllers; or Pneumatics & Electro-pneumatics (Figure 7). Students will take four classes per day for two weeks, taught by faculty from both the host and home institutions, and will participate in a project with local students. They will also attend five hours of lectures at universities in Budapest, Hungary, and Wien, Austria during their visit.

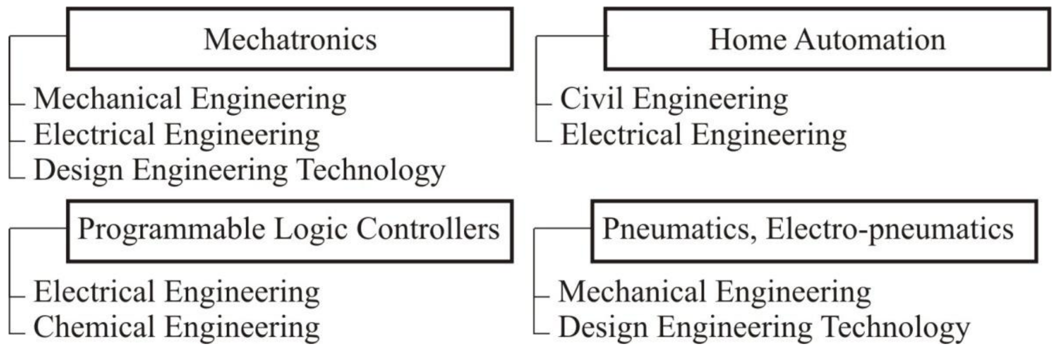

Figure 7: Project areas that would be offered as options

An important stage of this project was the development of a course syllabus, containing the course description, objectives, textbooks, and topics that would be covered. In addition, a handbook was developed to assist the student before they travel. The structure of the program handbook is given in Figure 8. Most of our students are from local communities, and it is assumed that they do not have previous international travel experience. Therefore, the handbook contains general program information, a pre-departure checklist, travel itinerary, a list of necessary documents, money and exchange information, health and safety guidelines, suggestions for packing, in-country information, consular information, and a basic vocabulary.

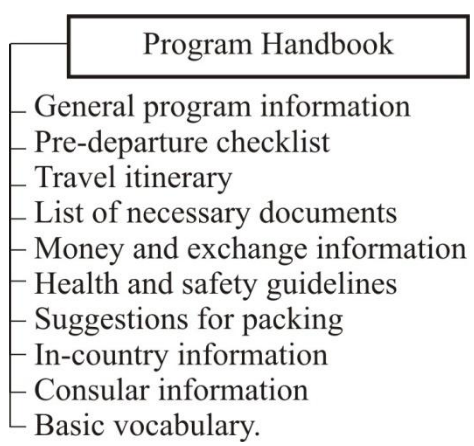

Figure 8: Program handbook structure

Two approaches for accommodations are being explored. The first option is staying in a local hostel. The second option is staying with local families. The latter option is preferred when less travel is involved. Host families will be screened prior to the program, using the same people and methods used by Princeton University's Bridge Year Program in Serbia[21]. Students will also be asked to serve as volunteers in the local American Cultural Center as a means to interact with local people interested in learning conversational English.

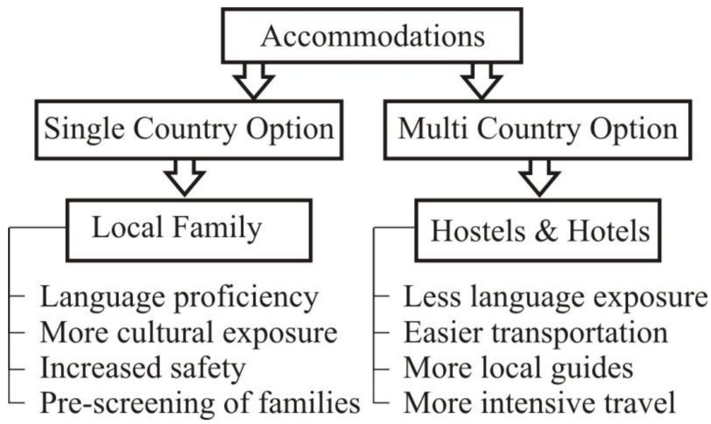

Figure 9: Different accommodation options

Conclusion

With the prevalence of right-sizing in today's global open-market economy, it's imperative that engineers develop additional aptitudes or skills that will distinguish them from their peers[2]. Industry needs a new breed of engineers: technically broad, commercially savvy, and globally adept. Global competence needs to become a key qualification for engineering graduates[21]. Students who have exposure to other cultures through focused coursework, interaction with international students, and classes led by foreign-born faculty may adapt better in a new working environment overseas. The educated American of today will have to be fluent in at least one foreign language, and knowledgeable about other countries and other cultures[6]. The authors have discussed the development of a study-abroad program that meets two of the three key criteria presented by the Council on International Education Exchange: travel to non-English speaking countries which are not common travel destinations for Americans. It is expected that participants will grow in their cultural competency through this program. This paper focuses on a development of a study abroad program. After implementation, details about the program's benefits, and responses from the participants will be collected and evaluated.

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