AC 2012-4069: ENGINEERING STUDY ABROAD PROGRAM ON SUSTAINABLE INFRASTRUCTURE

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Abstract

The issues facing the engineering community have become more complex. These issues include topics such as how to develop and maintain sustainable civil infrastructure systems and how to approach a problem using a multi-disciplinary approach. A method to address such topics in engineering education is being introduced at the University of Utah using a new study abroad program on the topic of sustainable infrastructure. The faculty-led program to Costa Rica, hosted by the Civil and Environmental Engineering Department and supported by the Environmental Studies Program, is being designed to combine engineering and non-engineering students to approach sustainable infrastructure planning, design, construction, and operation from a multi-disciplinary perspective. The goal of the program is to provide engineers and non-engineers the necessary broad understanding of infrastructure and in-depth technical skills to enable them to create more sustainable solutions. One key aspect of this engineering study abroad program is the integration of the learning activities with the location of the study abroad experience. To accomplish this integration and the goal of the course the instructors developed a set of learning activities including a team project, case study analysis, research paper, and individual and team assignments that will require the students to work in multi-disciplinary teams, learn from examples and professionals in Costa Rica, and make connections from their experiences in Costa Rica to practice in the United States. The paper will provide a description of the course objectives, content, and in-country activities. The focus will be how the pedagogy is coordinated with the international experience, applies e-Learning techniques, and incorporates multi-discipline activities.

Introduction

Study abroad programs are common at most universities and colleges with many programs being offered at quarter, semester, and year durations. However, the participation among engineering students is generally less than 5%, while participation from majors in humanities, business, and social sciences is generally more than 20%. This is not universal as there are a handful of programs that have a goal of 25% or more of engineering students participate in study abroad1.

There are numerous reasons for engineering students to participate in study abroad programs including:

- Enhance learning
- Improve independence
- Broaden horizons
- Enhance cultural diversity awareness
- Develop self-awareness and global awareness
- Meet general education requirements (e.g., international) for degree
- Become more competitive in the job market
- Comprehend international issues important to engineering
- Learn technology, construction practices, and engineering methods in other countries

Engineering departments and colleges also have strong reasons to offer study abroad programs. International experiences are known to be important for enhancing student learning and satisfaction. Offering these programs also enhances the internationalization of the curriculum, improves breadth of technology and engineering issues, appeals to larger international firms hiring engineering graduates, provide avenues to learn about globalization and international engineering projects to meet market trends, and opens new opportunities for international research collaboration.

Study abroad programs take many forms. The most common are exchange programs where reciprocal relationships are established between the home institution and numerous international institutions where specific courses and articulations are approved. A related form is exchange programs at affiliated institutions. The difference being reciprocal exchange programs have students pay tuition to the home institution while the affiliated studies programs have tuition being paid to the institution hosting the exchange student. In addition to exchange programs, other study abroad forms include internships and co-op, independent study and research, service learning (e.g., working with Engineers Without Borders), short-term credit and non-credit programs, and optional credit add-ons to semester courses (e.g., Plus3 program at the University of Pittsburgh). A difference in many of these options is whether a faculty member from the home institution (faculty-led program (FLP)) is directing the study abroad or if the students are self-directing or participating in a program directed at the host institution. Exchange programs are most commonly used by engineering students to meet general education or lower level basic engineering requirements. FLPs are more often used for upper level or advanced technical elective credits.

Although study abroad programs for engineering students are quite common, programs that seek to combine engineering and non-engineering students to address an interdisciplinary topic in engineering are less common. One program at Lafayette College integrates engineering and social sciences students\(^1\). The program combines students from engineering and non-engineering majors and is led by two faculty members – one from engineering (Electrical and Computer Engineering Department) and one from social sciences (Government and Law Department).

While there are numerous study abroad programs at the University of Utah and a very active Office that promotes it, participation from engineering students has always been small (typically < 2%). While the reasons for this lack of participation are plenty\(^2\), we suspect that two significant components include the large number of courses that engineering students must take and the specific rigor required of engineering courses to meet ABET requirements. This might prevent engineering students from obtaining the competitive edge that an international experience provides. Furthermore, engineering professors who could address these issues typically are busy with their own research and fulfilling the demands to keep current in this ever-changing field. In general, past study abroad experiences suggest reducing barriers and structuring opportunities to fit in the engineering curriculum will increase student participation\(^2\).
We decided to look into these issues. The first question is the length of the program. We found that there are semester-length programs set up by the College of Engineering that require special arrangement between universities so that the classes are equivalent. There are currently no FLPs offered at the University of Utah for engineering credit. We decided an FLP was necessary to meet our constraints. However, in order for an engineering FLP to be successful, it must be more than just a trip and it must have a topic which not only satisfies the strict engineering curriculum but also appeals to a wide audience.

After some thought, we decided that the topic of sustainability fulfills the aforementioned requisites. Sustainability has become a key element of engineering and university education the past decade and can be found in study abroad programs. For example, programs exist to study Renewable Energy (Washington University of St. Louis), Water Resources Engineering (Virginia Tech), Watershed Management (Virginia Tech), Sustainable Development, and Sustainable Technology (Washington University of St. Louis).

The Costa Rica engineering study abroad program at the University of Utah seeks to bring together engineering and non-engineering students in a way that supports an engineering-focused learning experience. Our pedagogical approach is to provide multi-disciplinary learning experiences for the students that build on experiences, case studies, and examples that not only stress the multi-disciplinary aspects of the engineering of infrastructure systems but also can be placed in the context of issues in Costa Rica. The next section describes the course, the multi-disciplinary elements, and the use of the international experience.

**Costa Rica Sustainable Infrastructure Engineering Study Abroad Program**

The multi-disciplinary engineering study abroad program at the University of Utah builds on an existing Environmental Studies Program. In the past the Environmental Studies Program has not included engineering students earning engineering credit. Our motivation was to develop a FLP taught by engineering professors that could meet the needs of engineering and non-engineering majors in terms of learning and degree requirements with our focus being on the engineering student degree requirements.

Currently, engineering study abroad programs are limited at the University of Utah, with two exchange programs being the only opportunities available. Overall, there is a robust study abroad program with almost 500 approved programs. But the involvement of engineering students has been limited and has only been to meet general education requirements.

The study abroad program we are developing is incorporating ideas from engineering and environmental studies. We have taken the strategy of building on an itinerary and environmental learning experiences in the annual Environmental Studies Costa Rica program. The goal of that program has been to provide environmental experiences for the student participants by touring environmentally significant sites including national parks, cities, and scenic areas. The program seeks to immerse students in environmentally and sustainability minded activities including where the students sleep, eat, and how they travel. Our objective has been to modify the itinerary
to provide exposure to civil engineering infrastructure examples and experts that support the reading and learning activities created for the new engineering-focused program.

Costa Rica is an ideal location for this program because of several unique characteristics of the country’s approach to sustainable infrastructure and development. From an engineering and infrastructure perspective, Costa Rica is a proponent of sustainable development incorporating sustainable civil infrastructure systems for transportation, energy production, and decentralized water services. Costa Rica also has a national policy perspective rooted in sustainability with a national mandate to seek sustainable solutions and support the strong ecotourism industry. Besides the already mentioned reasons, there is a large number of professionals that have been educated in U.S. institutions, which means people were available that could easily address a group of U.S. students.

The program learning objectives are:

- Explain the concepts of sustainability and resiliency and their relationship to civil infrastructure systems
- Describe policy and incentives related to infrastructure sustainability
- Estimate infrastructure system life-cycle cost
- Conduct infrastructure system life-cycle assessment
- Analyze cradle-to-grave of infrastructure systems and use systems thinking to value engineer system to achieve balance of cost, environmental impacts, and social equity
- Complete material flux analyses and specify sustainable material substitutions
- Assess functionality, capacity, and maintainability of infrastructure components and systems as they relate to sustainability and resiliency
- Determine sustainability indices for infrastructure projects
- Apply multi-criteria decision making to infrastructure project alternative analysis
- Recommend design and technological advances to increase sustainability and resiliency of infrastructure systems
- Recommend policy and social change to promote sustainable and resilient infrastructure solutions

Our study abroad program is designed to travel throughout Costa Rica with stays of 1-4 days in each location for a total duration of 23 days in country and more than 30 contact hours before departure and after returning. The program will include classroom time at least five days each week when in country with the instructors delivering lessons in traditional classroom space at universities and research institutes, as well as in non-traditional locations such as hotel lobbies, buses, national parks, and more.

We are planning for 24 students, with a reasonable balance of engineering and non-engineering majors. Students apply for the study abroad programs at the University of Utah and the selection of those permitted to participate will consider the major of the student. It is difficult to get non-engineers to participate in a study abroad program that is branded as “engineering”. Previous programs at other universities have sought to address this problem with the usual solution being the involvement of a faculty member from another college/disciplinary area. We are addressing this issue by partnering with the Environmental Studies Program. Environmental Studies has had a Costa Rica Study Abroad program for 6 years and have had the experience led by faculty from
a wide range of disciplines but the content has been focused on environmental studies. To
eliminate concerns from Environmental Studies students, we visited environmental studies
courses (Introduction to Environmental and Sustainability Studies) to describe the course and
answer questions. We also are working with the program directors to ensure the content of the
course meets their expectations.

Our major challenge with creating this multi-disciplinary course is retaining the academic
requirement to achieve upper level engineering credit, while permitting the program to be
successfully completed by non-engineering majors. This was a major challenge at our university
because faculty members in the Department of Civil and Environmental Engineering needed
convincing that the program would be more than a language or cultural immersion. The course
will include content on engineering economics, cost estimating, application of models, and
simplified spreadsheet analyses common in engineering consulting. How to engage non-
engineers in these activities required the use of team-based activities as described below.

The international experience is present in study abroad programs, but the question is whether the
international experience is interwoven into the topics and learning experiences. And also how the
course is designed to take advantage of the international experience to achieve the course
learning objectives. Others have sought to address these issues by treating the study abroad
program as a field experience in another country\(^3\), but these have been shorter programs focused
on visiting construction sites and interacting with other engineering students, faculty members,
and professionals.

We sought to increase the integration of the international experience by making the class topics
relate to the location in Costa Rica as much as possible through examples, exercises, and data.
We started in the program planning stage by identifying a course topic (Sustainable
Infrastructure) and lesson topics that can be tied to civil engineering practice in Costa Rica and
the United States. In this way we were able to find interconnections for the students, but also
identify areas we could effectively address with our individual areas of expertise. We also
developed a set of learning activities that will serve to combine engineering and non-engineering
students in ways that use their backgrounds and foundational abilities to address problems
requiring multi-disciplinary perspectives and skills. The learning activities were designed to
integrate the international experience into the course learning objectives. A brief description of
the activities designed follows.

**Team Project**

A team project will serve as the most important activity. Team composition will be assigned by
the instructors based on student data to create multi-discipline teams of sufficient diversity in
background and scholastic aptitude. The assigned project will be to provide explanations,
examples, and solved exercises related to a set of sustainability topics mirroring the sustainability
topics to be covered in our course. The expectation is for the multi-discipline teams to
collectively produce the equivalent of a Sustainable Infrastructure e-textbook. We will require
each team to create a wiki that will serve as the basis for their team project with entries made
daily (or as Internet access permits). Following the return to the University of Utah at the
conclusion of the study abroad experience, the wiki compositions will be compiled by the teams
into a compendium with sufficient quality, depth, and breadth to potentially serve as a textbook for the next offering of the course. Teams will be required to incorporate into every section they complete examples, data, and solved exercises related to Costa Rica. In addition, they will be required to relate the Costa Rica information to practice in the U.S. and provide examples, data, and solved exercises for the U.S. Through this project we expect the students to not only be able to relate the topics of the course to practice in Costa Rica but also the U.S.

Case Study

A case study analysis will be another required multi-disciplinary team assignment that will be tied to Costa Rica and help link back to the U.S. The objective of the case study will be to address a sustainability problem related to an infrastructure system and analyze from the perspective of Costa Rica and the U.S. The case study shall include review of project background, analysis of potential alternative solutions, and recommendation of a solution. Use of life-cycle cost analysis and value engineering, Triple Bottom Line accounting, assessment of social implications, assessment of policy and financing, and other sustainability topics covered in the course will need to be addressed. The multi-discipline team will need to exercise both engineering and non-engineering skills to address the case study analysis due to the requirement to consider multiple objectives. The completed case study will be incorporated into their team project, wherever it may fit best.

Research Paper

The research paper will be an individual assignment with the student selecting the topic. The topic must fit within the student’s major. The research assignment will require students to compile information on a topic of their choice. The Costa Rica experience will be woven into the research paper by requiring students to include examples and data from Costa Rica and relate to the U.S., similar to the team project. And again the research paper product is expected to be incorporated into the team project assignment by providing additional depth across a range of topics from all students.

Site Visits

Lastly, a key aspect we chose to integrate the Costa Rica experience into the learning objectives is to schedule an itinerary that resembles a 3.5 week tour of the country. We will begin the program in the capital city of San Jose where we will meet with researchers and students at the University of Costa Rica National Laboratory for Materials and Infrastructure (Lanamme) and at the Institute for Sustainable Development. We will proceed to travel to six different locations over 23 days, returning back to San Jose to conclude the study abroad and return to the U.S. At each location we have day trips planned to infrastructure sites including new highways, renewable energy generating facilities, water treatment facilities, wastewater treatment facilities, sustainable developments, and more. Each of these visits will be tied to the topic of the program planned for that day.

Overall, each day will include classroom time, learning exercises, and project/case study/research paper work times. And in all cases the activity will be tied to Costa Rica and our
current location on the tour. And in some way the topic will be tied back to practice in the U.S. Making these linkages each day will help us achieve our learning objectives.

Conclusion

Engineering is becoming a global and interdisciplinary field. Universities are beginning to provide learning experiences in international settings that seek to broaden student perspectives and their multi-disciplinary problem solving abilities. However, engineering study abroad programs are lacking, especially those that are specifically designed to take advantage of the international exposure to enhance the engineering learning outcomes. The engineering study abroad program described in this paper provides a faculty-led study abroad program that brings together engineering and non-engineering students in a way that achieves engineering-specific learning objectives. In addition, the program is designed to fully integrate the international experiences into achieving the learning outcomes.

The program topic of Sustainable Infrastructure is perfectly suited to these objectives because sustainability requires a multi-disciplinary approach and choosing Costa Rica is perfect for providing examples and experts that have been addressing sustainability in infrastructure systems.

With this paper we provide an overview of our new program. On this inaugural program we intend to collect assessment data and observations of effectiveness of integrating the international experience and program learning objectives. We will report these findings at the conference (the study abroad is scheduled for May of 2012) and in a subsequent paper at next year’s ASEE Annual Conference.

Bibliography

