AC 2007-2199: THE ROLE OF SMALL SCALE INTERNATIONAL SERVICE PROJECTS IN ENGINEERING EDUCATION: THE STUDENTS' PERSPECTIVE

Sarah Freeman, Tufts University

Ms. Freeman is a current MS graduate student in the Civil and Environmental Engineering department at Tufts University. She received her BS degrees in Mechanical Engineering from Tufts and served as the 2005 President and co-founder of the Tufts Engineers-Without-Borders student chapter. Her teaching and research interests lie in the areas of water resources, sustainable development and appropriate technologies.

Jonathan Crocker, Tufts University

Mr. Crocker is a current senior in the Civil and Environmental Engineering department at Tufts University. He served as the 2006 President the Tufts Engineers-Without-Borders student chapter. His research interests lie in the areas of groundwater contamination, sustainable development and appropriate technologies.

Chris Swan, Tufts University

Dr. Swan is an Associate Professor in and current chair of the Civil and Environmental Engineering department at Tufts University. His current interests are the reuse of recovered or recyclable materials and sustainable construction.

The Role of Small Scale International Service Projects in Engineering Education: The Students' Perspective

Abstract:
International service projects are increasingly recognized as a way to prepare students for the global marketplace. Project-based service learning is a valuable educational tool, and expands upon a traditional engineering education. Accordingly, increased opportunities for this have been provided to students through various national and university institutions. In the past three years, students from Tufts University have initiated projects in Ecuador, El Salvador and the Tibet Autonomous Region. These projects provide diverse perspectives, from which important lessons can be extracted.

This paper will address lessons learned from student-run international service projects. Challenges and benefits experienced by the students during project formation, planning, and implementation will be considered. Attention will be paid to the viability of student perceptions on roles of students and faculty mentors. It is suggested that these projects are most effective as an educational tool when sufficient responsibility and accountability is placed on the students during all phases of the project. A detailed analysis of past projects is necessary in order to improve the potential benefits of international service projects to students.

Introduction

In a traditional engineering education, course work is typically either from a book or isolates a certain stage of a project, or a certain component of a technology. The Accreditation Board for Engineering and Technology (ABET) requires that an engineering program must give students an ability to function on multi-disciplinary teams; an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability; an ability to understand the impact of engineering solutions in a global, economic, environmental, and societal context; as well as a knowledge of contemporary issues[1]. Students traditionally do not experience project based learning, and engineering design until their junior or senior year of study.

International service projects provide the opportunity for students to work together in teams and experience designing for real world constraints early in their education. By having the responsibility of making all decisions related to projects, students learn how real-world engineering problems are approached. Rather than solving isolated engineering problems, students learn how to make crucial assumptions and decisions about each phase of a project. Service learning also gives students a motivation for doing work, as the results are tangible, and can improve peoples' quality of life. In today's global marketplace, an understanding of issues that face the international community in which we exist is important. International service projects aid students in gaining an understanding of global issues that they will face in their lifetime.

In this paper, the Tufts chapter of Engineers Without Borders (EWB) will be used as a case study of how international service projects can enhance a traditional engineering education. This Tufts organization instills responsibility and leadership in students by placing students in charge of

decision-making, and by holding students accountable both for the successes and failures of their work on projects. This student led approach results in many benefits but also presents many challenges.

Background

The Tufts University Chapter of Engineers Without Borders was founded in the fall of 2004 by four students; Sarah Freeman, Hoi Yee Lam, Grant Sharpe, and Teren Peck. From founding the organization, to creating a structure, to designing technologies, to implementing projects, these students led the club through its first year at Tufts University. Students have continued to drive each successive stage of the organization's expansion. In the first year, students had to overcome many challenges that inevitably arose as the first project involved sending a travel team to Gyamthang, a rural community in the Tibet Autonomous Region, to build a composting latrine and a solar cooker[2].

In Tufts EWB's second year, faculty and students proposed a variety of new projects that could be pursued. The growing membership in the organization allowed for two of these to be pursued, one in El Salvador and one in Ecuador. The El Salvador project concentrates on water supply and sanitation and the Ecuador project focuses on community-based natural resource management. Both of these projects were proposed in conjunction with non-governmental agencies with long standing traditions their respective regions.

Student and Faculty Roles

The Tufts Engineers Without Borders program is a student run organization, and therefore students are responsible and accountable for success as well as failure. The structure provides opportunities for students to learn leadership skills through experience. Students also learn how to assess critical decisions through experience. International projects are a medium for education, and can create actual change in the partnered communities, but through this very nature, they also introduce risks to the students, professors, and the communities involved.

The student management of all three international projects is one of the most challenging and valuable aspects of Tufts EWB. The responsibilities of management permeate every level of the organization and can be overwhelming at times. About twenty-five percent of the organization’s participants elect to pursue management to some degree, and have the opportunity to develop a distinctive skill set. Although management classes are valuable, the experience of working on a long-lasting, multiphase project allows for personalized and real-time learning.

Leaders of different groups must learn how to organize the efforts of students with different skills and disciplines, as well as learn to coordinate their efforts with those of different subgroups. In the Fall of 2006, the El Salvador project team was simultaneously designing and prototyping a water filtration and distribution system, budgeting and planning the next two trips to Arada Vieja, and working with the community health group to get approval for a health survey for the upcoming trip. Towards the end of the semester, the project leads were communicating with the El Salvador based non-profit Epilogos Charities, and making necessary preparations for a 3 week assessment and implementation trip. The ability to prioritize tasks and manage time is a skill developed by necessity. Without effective leadership and support from team members at each level of the club, a project would not be successful.

Over the course of the last three years, many lessons have been learned through the success and failures experienced at different stages. As the club has grown in size and scope, club organization, fund raising, trip planning, and project design have become increasingly complex. In order to continue to improve on the clubs impact on the university as well as on the partnered communities, upperclassmen who have participated in the program longer are responsible for organizing the clubs structure and training younger members. The ability to mentor peers is a very relevant skill for real world problem solving. By mentoring younger students, leaders in EWB learn how to effectively communicate technical and non technical information to others.

Management of the organization involves making critical decisions. The amount of responsibility placed on students hold risks. Students set the tone of the management, and the amount of faculty input depends on the students' decisions. Because these projects are very real in nature they also have very real consequences. This demands the wisdom of knowing of when to ask for help. The student-faculty interactions that ensue provide the opportunity for interactions with faculty in an environment that is rarely experienced by students.

Although the program is student run, faculty advisors play an indispensable role. Because of the real world consequences involved in projects, it is necessary that faculty advisors are consulted for technical assistance in design of technologies and planning of trips. Risks associated with international travel include possible harm to traveling students and faculty, as well as harm to the communities associated with the project. For this reason faculty are available for advising and oversight of decisions upon students' request, and multiple times each semester the project teams must report to faculty advisors for review and assessment.

Project Process

The process involved in working on international service projects can be split into three categories: formation, planning, and implementation. Each aspect of the project process has unique characteristics that include benefits and challenges for students and faculty advisors alike. The past projects in Tibet, Ecuador and El Salvador have been able to expand on traditional engineering education for a number of reasons. Skills learned include, leadership, working on multidisciplinary teams, real world problem solving, and mentoring.

These skills are learned out of necessity for the success of the club, but also because students are invested in their work. Because projects are implemented in communities where they can be significant for the welfare of community members, the success of the work is very important. By having responsibility and accountability lie with the students, a sense of ownership results that leads to a commitment to a project that will have long lasting results. As one student remarked, "nothing makes me happier than knowing that the hard work that I am putting in to this group on a daily basis is going to improve the quality of life of someone less fortunate than me day after day[3]." This drive is displayed in every stage of a project.

Formation

The process of formation and initiation of a project allows for a complex and unique opportunity for student decision-making. Within the context of the projects pursued by Tufts EWB, formation and initiation occur on two major levels. The first level is the structuring of the

organization. The second is the choice and definition of specific projects. Each level presents benefits as well as challenges to the participants.

Structuring the organization and defining projects requires significant comprehension of the available capacity and resources. Knowing the limitations and scope of the organization requires insight that can only be learned from experience. For Tufts EWB, this is possible because of the participation by students with varying years of experience, as well as by the accessibility faculty advisors. As student experience and available resources have grown over the last three years, the group of students participating in EWB has expanded. The decision to pursue the El Salvador and Ecuador projects out of the twelve proposed projects was based on many factors including previous student engagement in those areas. The organization's investment in student initiated projects provided for highly motivated groups.

Planning

On-campus planning for project implementation is a crucial component of international service projects. Students work throughout the academic year designing the appropriate technologies to be implemented. Design work is highly collaborative in nature, as the technologies being designed include aspects from multiple engineering disciplines. Initial design work is the responsibility of the students involved in Tufts EWB. The second stage of technology design involves faculty review of student progress, followed by frequently forgotten redesign stage. Technology prototyping is an essential part of technology design, as it provides a method of testing the technologies and construction methods under ideal conditions before designs are taken to the field.

The 2004/2005 academic year, the first year of Tufts EWB's existence, was largely spent working towards the implementation of a composting latrine and solar cooker in rural Tibet. The composting latrine is one example of the technical achievements of Tufts EWB students. Because this design included elements of mechanical, civil, environmental engineering the design depended on the participation of a diverse and representative team. The design and implementation plans were then assessed on technical merit by engineering faculty and on socioeconomic viability by faculty and students from anthropology and international relations. While full-scale prototyping of this was not possible, the design was modeled structurally and thermally to ensure it's technical viability given the environmental constraints of the Tibetan plateau[4]. The success of this process was realized in the field, when students and faculty were able to adapt and implement the design given unpredictable local constraints.

Since the 2005 implementation trip to Tibet, Tufts EWB has formalized the methods for assessment, design, and implementation. The process for review of design and implementation plans now includes the review of pre-implementation reports and presentations to a board composed of fifteen faculty members from the schools of engineering, and arts and sciences. The formalization of the planning process has also allowed for more involved pre-implementation prototyping. For example, the slow sand filtration experience included the variation of multiple design parameters and comprehensive water quality testing[5]. The technical experience provided through these efforts has reinforced and expanded upon on the traditional classroom learning experience.

Implementation

Although international trips are a small aspect of the projects in terms of time and labor, they often become the focal point of the projects. Nothing brings the same kind of validation, motivation, or sense of urgent reality as effectively as living and working side by side with members of a remote community that suffers from drought and disease on a yearly basis. The inspiration that is created by this type of work takes a different form for each student, and allows students to put their role as future professionals into a global context. One student recalled his experience in El Salvador, stating that it "has made me appreciate the language skills I had overlooked my first couple years [at Tufts University]. It also made me appreciate the circumstances I am in and the opportunity I have to help others[6]."

The on ground experience is much more than just a motivation. The realities of the situation also require a tremendous amount of planning, adaptability, and cultural sensitivity. An example of the planning and adaptability necessary occurred during the last implementation trip in El Salvador. Two days into the slow sand filtration implementation trip this past winter discovered that the shop that had been previously contacted for a specific grade of sand, in fact, did not have this[7]. This discovery, of course, was not made until the group walked into the shop in person. What is to be done when the key element of a design is no longer available? In one word, adapt. Trays were constructed with fine wire mesh that had been brought as backup, to manually sieve the necessary sand grain size. Equally important to adaptability is cultural sensitivity. Upon arrival in Gyamthang in the summer of 2005, the travel team discovered that a yearly harvest festival was taking place. Instead of pushing forward to conduct tests or build, it provided the perfect opportunity to do something even more important: build trust within the community by participating in the festival. The ability to be flexible and to pick up on social or cultural cues is not easily taught from a Power Point Presentation. This type of hands-on experience is truly invaluable.

The discussion of implementation of any international project demands that attention be paid to the safety of students and the communities they work with. Safety is always an important and sensitive issue that arises in the discussion of travel and the realization of a project. It is also where the roles and responsibility of students and faculty blurs. The experiences provided by international projects come with risks that must be considered. Being prepared for situations that may not be comfortable for travelers is also important. Over the past year, in addition to a Technical Advisory Committee that is provided by the National Chapter of EWB, Tufts EWB has added an internal Faculty Review Board to vet both designs, implementation, and travel plans. There is a natural difficulty for students who have spent countless hours working on preparations, to understand that at times it is necessary to defer to the more experienced and conservative judgment of a faculty advisor. Ultimately, open discussions on these subjects result in a beneficial relationship between faculty advisors and students, particularly amongst travel team members.

Conclusion

In the experience of Tufts Engineers Without Borders, international service projects have proved very useful for educating engineers. The model of student initiated, managed, and implemented projects motivates student and ensures a certain caliber of work. While students are held

accountable for all aspects of the projects, mentor participation remains vital particularly with respect to risk mitigation. Students feel that there is a great benefit to their education when concepts of project-based learning are expanded to include a sense of service and provide a global perspective. More research on the models used for international service projects is needed to analyze the relative benefits provided to engineering education.

Acknowledgements
The authors would like to thank the Tufts University and the many centers and departments for their past and continuing support in helping establish these projects. This includes:

Jonathan M. Tisch College of Citizenship and Public Service
Tufts Institute for Global Leadership
School of Engineering
School of Arts and Sciences
Frederic Berger

Bibliography

1. Engineering Accreditation Commission, Accreditation Board for Engineering and Technology, Criteria for Accrediting Engineering Programs Effective for Evaluations During the 2005-2006 Accreditation Cycle, November 2004.

2. Matson, D., Freeman, S., Sharpe, G., Swan, C., "International Citizenship and Global Service Leadership: The Role of Interdisciplinary Teams in Engineering Education," Proceedings of the 2006 American Society for Engineering Education Annual Conference & Exposition, Chicago, IL, June 2006.

3. Siegel, K.,, "Application for Travel Eligibility," Tufts Engineers Without Borders. November, 2006.

4. Freeman, S., "Context and Design for Appropriate Sanitation in Gyatsa, Tibet." May 2005.

5. Tufts Engineers Without Borders, "El Salvador Technical Report: Implementation of Slow Sand Filtration." January 2007.

6. Kelly, B., "Application for Travel Eligibility," Tufts Engineers Without Borders. November, 2006.

7. Tufts Engineers Without Borders, January 2007.