

AC 2007-1294: INTERNATIONAL COMMUNITY-BASED PROJECTS AND ENGINEERING EDUCATION: THE ADVISOR'S VIEWPOINT

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International Community-Based Projects and Engineering Education: The Advisor's Viewpoint

Abstract

There has been tremendous growth in the interest of engineering students to perform community service projects on an international scale. National organizations, such as Engineers Without Borders and Engineers for a Sustainable World, have provided a mechanism for students to do such works and further develop both their technical and non-technical skills. Over the last few years, student teams from Tufts University, many times teaming engineering with non-engineering students, have undertaken projects in Ecuador, El Salvador, Ghana, and Tibet. Each project presents unique issues, but there are also elements common to all.

This paper describes three projects and presents some of the lessons learned in forming, orchestrating, and delivering meaningful learning experiences for students from the viewpoint of the faculty advisor. Both positive and negative lessons can be found in areas such as project organization, management, and ultimately in delivery; proper reconnaissance and trip planning; advisor attitude and expectations and how they may differ from those of the students; and assessment of real-versus-perceived benefits from the perspective of educational benefit to the student. We conclude that international, service-learning projects are a valuable pedagogical tool for educating engineering students when expectations are fully communicated and transparent. Proper assessment of these efforts would more strongly validate the use of such projects.

Introduction

In engineering education, international projects provide students the opportunity to apply their technical know-how in multidisciplinary teams of engineers (civil, mechanical, chemical, etc.), natural scientists (geology, chemistry, physics, biology, etc.) and other specialized disciplines (microbiology, geochemistry, toxicology, etc.). However, effectively developing solutions to environmental problems often involves mastery of critical non-technical subjects such as project management, communication, local and regional politics, economics, culture, and the concerns of affected stakeholders.

Tufts School of Engineering has been involved in several projects focused on environmental issues and public health. Many of these efforts have involved projects and/or activities in local (Boston, MA area) communities and provide the opportunity to apply concepts of community-based service learning (CSL) in engineering education^{1, 2, 3, 4}. There is a growing literature on the value of CSL as a tool to help students develop deeper appreciation of engineering concepts as well as to communicate their engineering solutions to both technical and lay audiences^{5, 6, 7, 8}.

In the last few years a number of international projects have emerged that have taken teams of students (each with faculty advisors) to locations such as Ghana in West Africa and the Tibet region of China^{9, 10}. Student teams, often a mixture of undergraduate and graduate students from various disciplines, need the support and guidance of one or more faculty advisors. Depending on the project, the faculty advisor may serve as the lead in project orchestration or in a more limited role of as an equal (yet more experienced) team member. The value of these projects to the learning experience of the students involved can be significant as well as life-affecting. However, the formulation of appropriate projects as well as designing and implementing

solutions in an international context, especially in low-income nations, poses several unique challenges.

This paper presents some of the lessons learned in developing, organizing and completing these projects from the perspective of faculty advisors (each of the co-authors has served as faculty advisor in one or more international projects). Three projects are described with faculty advisors providing insights on project team development and organization, travel coordination issues, project delivery, and personal reflections of the benefits and detriments observed during and after project participation. Finally, the paper provides some concluding remarks on how international projects can be more successful as a result of improved advising.

Project 1: Kwabeng, Ghana - Schistosomiasis Control in a Community Impacted by Surface Gold-Mining

Brief Project Description:

Between 30-40% of the children attending elementary school in the town of Kwabeng (population c.6,000) in the Eastern Region of Ghana (West Africa) have schistosomiasis. Schistosomiasis, also known as Bilharzia, is a water-borne parasitic disease caused exposure to flatworms of the genus *Schistosoma*. Over 200 million people worldwide have schistosomiasis with another 600 million estimated to be at risk. Schistosomiasis accounts for a disease burden of 1.76 million Disability Adjusted Life Years (DALY) and 15,000 annual deaths, this ranks second behind malaria in terms of public health importance in tropical and subtropical areas¹¹. It is estimated that over 80% of the infected population lives in sub-Saharan Africa, where water resource management is poor and disease intervention resources are scarce. People become infected when they come into direct contact with water containing schistosomes. The symptoms of Schistosomiasis haematobium, the most common form of schistosomiasis in western Africa, include bloody urine and anemia. There is growing concern that the urgency of control efforts for schistosomiasis, and other so called neglected waterborne infectious diseases, has waned as greater attention has been focused on other major killers in the region¹².

The above forms the rationale for Tufts efforts as we seek to integrate both primary prevention and case finding and treatment. Since 2003, Tufts has been involved in developing and sustaining a program to study the area and to develop remedial efforts that will hopefully reduce (if not eliminate) these outbreaks. These efforts are predicated on the hypothesis that the recent increases in schistosomiasis rates in Kwabeng have been triggered by changes to the hydrology and hydraulics of the local watershed due in large part to gold mining impoundments constructed within the watershed. These hydraulic alterations improved the habitat for *Bulinus* snails, the intermediate host in the lifecycle of the flatworms (*Schistosoma haematobium*).

Kwabeng, Ghana Project Goals

The goal of this project is to help bring about community change that will lead to a sustained reduction in the incidence of schistosomiasis in school children in Kwabeng. This will be achieved by providing treatment to sick children, identifying hot-spots of exposure, developing education programs to help prevent further infection, and establishing effective working relationships with community members including the mining companies. There are five desired outcomes of this project: (i) children who have schistosomiasis will receive treatment; (ii)

schistosome exposure hot-spots along the Awusu River will be identified; (iii) education materials will be developed and disseminated to help school children avoid exposure to schistosomes in the river; (iv) as a result of the first three outcomes, there will be a significant decrease in the rates of schistosomiasis in school children in Kwabeng; and (v) the mining company will be an active participant in finding ways to reduce schistosome exposure along the river.

In five trips, various Tufts' student teams have visited Kwabeng to evaluate the conditions that lead to schistosomiasis outbreaks. Specifically, efforts have included two separate disease prevalence studies, providing drugs to Ghana Health Services for treatment of all self-reported and field laboratory confirmed cases, conducting Cercariometry studies sufficient to identify "hot spots" of disease transmission, and evaluating methods to manage water resources in the area.



Figure 1 Kwabeng, Ghana Efforts in 2005: a) Assessment of River Flow Characteristics and b) Presentation to Local Residents

Initial efforts in Kwabeng included characterization of the nature, complexity, and extent of the problem as well as social and logistical constraints. The on-going work in Kwabeng now focuses on three major categories of interventions:

- controlling the re-entry of eggs, from human feces and urine, capable of sustaining the life cycle of the disease,
- controlling the intermediate host (snails), and
- providing engineering interventions which allow the use of safe water for bathing, washing and playing.

These interventions were evaluated based on cost, feasibility, community acceptance, efficacy, and sustainability. Based on the work to date, the best corrective actions for implementation include:

- increase river velocity by river restoration to reduce the snail population,
- community-wide campaign to develop alternative potable water sources (wells), and
- continuous public health education along with screening and treatment events.

Faculty Advisors Views

Project Team Development and Organization

This project was presented by faculty advisors to prospective student participants within a Capstone Engineering Design Course for second semester seniors in Civil and Environmental Engineering. To date, the project has had two cohorts of undergraduate students: one in February 2004 (N = 6) and January 2006 (N=7). Both cohorts were determined by student interest in the project's proposed effort at that time. Although the course is offered in the Spring semester all participating students were required to commence work at the outset of the preceding fall semester. This allowed for trip planning, fund raising (particularly in the first year), immersion in the relevant literatures, and the specification of tasks and responsibilities to be completed in the field. It was also thought that this extra requirement would dissuade casual interest on the part of students and ensure motivated participants.

As a Capstone Project the primary emphasis in terms of deliverables were to require the students to engage in the solution of a design problem. Over the course of this project these deliverables have taken on many forms including river and human epidemiological surveys, a consideration of possible health education programs to reach school-age children, mapping of exposure hot-spots along the river, mapping of the town with inclusion of principal landmarks and civil infrastructure components, the design of wells and water distribution systems as well as other engineering interventions

Travel Coordination Issues

The rise and fall of projects which seek access to local people and their communities is dependent on strength of the connection to the target community. In the case of this project a great benefit to the project teams have been the contributions of Kwabena Kyei-Aboagye whose family lives within the field site of this project. Mr. Aboagye originally involved the Tufts team as a result of his friendship with John Durant. As a result of Mr. Kyei-Aboagye's familiarity with the culture, language, (the spoken dialect is Twi though being a Commonwealth nation English is an official language of the country) and community structure he assumed a central role in helping the advisors to arrange meetings with local officials as well as helping with travel logistics.

On-Site Project Delivery

The challenge of all field work is that it represents a thrilling leap into the unknown. This is particularly true when working the domain of international projects. It forces students and faculty alike to be resourceful and innovative in overcoming unanticipated obstacles such as school holidays which were not known to the study team conducting epidemiological surveys to the locating of a bicycle wheel rim to serve as a uniform measure of square area in snail density studies to learning that bloody urine in boys is a favorable sign of maturity. The ability to overcome obstacles offers challenge and ultimately satisfaction as the work must move forward.

Personal Reflections

The overriding sentiment which arises in reflecting upon the Kwabeng project is the critical nature of team work which must be present if the field work is to be a success. The Kwabeng Project seeks to offer the student and faculty member alike the ability to view an environmental

health problem in its entirety, from its source, the routes of transmission, the expression and pathogenesis of the disease in human populations and ultimately in proposing engineering interventions that are acceptable to the local community and feasible to implement. One of the largest problems confronting the project team is how to ensure and promote “buy-in” from a critical mass of the local community. The principal source of this input is presently derived from a Kwabeng Project Advisory Committee which was formed at the beginning of the project. At present we are attempting to enlist Ghanaian colleagues who can help more fully create a sustainable platform for considering and selecting possible interventions that will meet with wide community acceptance in both the short-term and long-term time frames.

Project 2: Gyatsa Tibet – Public Health and Solid Waste Treatment

Brief Project Description:

The Tufts student chapter of Engineers Without Borders (EWB) completed a successful assessment and implementation visit to a community in Gyatsa China, Tibet Autonomous Region (TAR), over a four week period during the summer of 2005. The project’s local sponsor was the KunDe Foundation, a non-governmental organization (NGO) formed by British doctors’ desire for health education and outreach for provinces in Tibet and Southern China. The initial scope of work involved the students working at Tufts to develop the designs that were then to be presented to Chinese officials and Tibetan villagers to ascertain what direction the program should take to best support the target community. The travel team then would conduct on-site assessment tasks and build a solid foundation for continued program implementation.

The Tufts student chapter of EWB is strongly controlled by its students. Students must assume the leadership role in project development, design, implementation and funding. Engineering students took the technical lead in developing three preliminary designs of select components (as determined by the sponsor) of the project: a water quality assessment process, solar decontamination of medical wastes (via a modified solar cooker), and construction of a composting latrine. Originally, the goal of the effort was intended to be an assessment visit with the goal to meet with KunDe officials and establish a working rapport with the local Chinese officials and the Tibetan community. However, while on-site, the effort was expanded to include assessment and implementation of the preliminary designs. The KunDe Foundation was unbelievably supportive. They encouraged full implementation for all three projects and offered invaluable assistance by providing two translators, supplies, camping gear, vehicles, water quality assessment kits, and introductions to major players in the Chinese/Tibetan health ministry. The visit was successful in terms of technical design coordination, project planning, international educational experience and personal leadership growth.

Faculty Advisor Views

Project Team Development and Organization

One of the primary successes of the project was the pre-trip preparation with respect to technical concerns. Students, many of whom did not take the trip to Tibet, accomplished much of the design activity. For example, civil engineering students trained each other in how to conduct the water quality assessment and purchased supplies to conduct testing on-site. The solar cooker was designed to function either as a cooking device or for disinfecting medical wastes. However, a number of issues during travel and on-site implementation did arise. For example, the almost exclusive need for cash during the trip was not seen. Use of credit cards was virtually impossible

leading to the complete depletion of cash reserves. The day-to-day living arrangements (food, water, shelter) were not pre-planned.



Figure 2 Completed Latrine in Tibet with Tufts EWB Travel Team Members

Travel Coordination Issues

Trip planning was not without challenges. Examples included:

- Despite earlier attempts, travel visas were still not obtained until the day of departure.
- In their zeal to protect foreigners, Chinese officials are overly cautious about granting travel approvals (especially from a closed region to another closed region).
- Upon arrival in Tibet, severe delays were encountered in scheduling our departure for the target community.

The key to success was to embrace an opportunistic travel mode and to have flexible travel arrangements.

On-Site Project Delivery

Challenges to the effort continued upon arrival in Beijing, China. One of the project advisors had a change in heart and decided to leave the team and return home after only one full day in China. It took a week to travel to Beijing to KunDe's headquarters, and then another week arranging travel permits from the KunDe to Gyatsa; leaving two weeks in Gyatsa to work on the project. Also, while waiting at KunDe's headquarters, a team member came down with severe altitude sickness and had to be evacuated to a lower altitude. Another concern was that the water testing kits could not be brought across the international borders without far more paperwork than was able to be arranged before leaving. Despite all these setbacks, the team's resolve was

not dampened but focused, and the project is considered a success as all three tasks, solar cooker, latrine, and water quality assessment, were completed.

Personal Reflections

The accomplishments on the trip pale in comparison to the personal growth and leadership skills that developed in the students on the trip. A “team” design concept was reinforced when the duties of the evacuated team member (latrine design and construction) were quickly assumed by another member. Individual responsibilities continued to shift so that all efforts could be supported. This can be owed to the technical preparations prior to the trip where expected tasks were well defined and various team members were qualified to implement each component.

A particular point of friction was the multidisciplinary nature of the team - it was both a strength and a weakness. Non-engineers felt trivialized and when they attempted to try to influence design decisions because they had not been part of the pre-trip technical planning activities but rather had concentrated on cultural issues. In many instances prolonged discussion delayed key steps in the implementation and executive decisions were not received well. On considering the negative team dynamics that were evolving, the team implemented a better creative solution. Sub-teams addressed the controversial decision with a known time limit imposed by the progress of the construction. We had a pre-arranged back-up plan that all parties agreed would be implemented if the alternatives did not pan out. Everyone felt empowered and conflict was defused. After construction, when the community education phase was in full swing, the importance of the role of the non-engineers became readily apparent, but unneeded stress could have been avoided had all students been involved earlier in the planning process. Clearly defined roles with written objectives would have minimized some of the hurt feelings.

The lack of privacy also created unwanted friction. The villagers are curious and want to observe us at all times. It often felt that we were on the wrong side of the bars in a zoo. Privacy when ill was a prime concern. Culturally it is acceptable to stare in Tibet and communal toilets were a particularly difficult experience. Use of the Asia “squat-plate” design is hard enough without an audience.

Community interaction was greatly enhanced by several student-initiated activities. Digital cameras with large forward-tilting display screens were a huge hit. People who can see themselves prior (or during) the taking of the picture crowd around and laugh and call friends over to socialize. Candy and food sharing is also a great ice-breaker, especially for the young who draw in the older village members. Soccer and Frisbee tossing were especially attractive. The younger boys start, but the girls can be drawn in readily. Older women and men watch, to laugh, and are soon involved by “stray” shots. Boundaries were always fuzzy, and the faculty leader was particularly torn between allowing students the freedom to experience as many spontaneous cultural exchanges as was possible, and controlling the group so that no detrimental situations could evolve.

Project 3: Tabacundo, Ecuador – “Green” Residence and Community Health Assessment

Brief Project Description:

In the summer of 2006, Tufts Engineers Without Borders (EWB) chapter fielded a team of six that traveled to Tabacundo, Ecuador. This effort was to assess the possibility to create a model “green” residence that can serve as a model in teaching Ecuadorian school children the principals of resource efficiency in building practices as well as a starting point for spreading green building practices in Ecuador. An existing house on the Hacienda Picalqui, owned and operated by the Ecuadorian non-governmental organization Fundación Brethren y Unidas (FBU), is to be renovated into this “green” residence. In addition, the trip allowed the team to 1) gather additional information on the communities served by FBU on what their needs may be; 2) establish a partnership with FBU; and 3) initiate construction of a bio-gas unit, which converts pig waste into methane gas that can be used for fuel to a modified cooking stove.

The travel team consisted of the one faculty advisor and five students with majors ranging from engineering to community health major. While in Ecuador the team was able to:

- Make measurements of an existing residence on the Hacienda (the volunteer house) for future conversions/additions for a “green building” that would showcase simple, appropriate technologies that are more environmentally sound and promote more sustainable housing.
- Participate in construction of the bio-gas unit that would use pig waste as fuel to would produce enough gas to supply two to three residences.
- Conduct public health surveys of community members and leaders at the Hacienda and in the Intag, a region north of Quito.
- Observe the eco-agricultural efforts that have been espoused by FBU over the last few years.
- Initiate a dialogue with FBU volunteers and workers about their work and what they see as the future of FBU and their efforts.
- Initiate contact with Escuela Politecnica Nacional in Quito (<http://www.epn.edu.ec/>) to begin to establish student and research exchange projects and programs with Tufts.



Figure 3 Construction of Bio-Gas Trench Unit in Ecuador

Faculty Advisor Views

Project Team Development and Organization

As noted for the Tibetan project, the Tufts student chapter of EWB is strongly controlled by students who assume the leadership role in project development, design, implementation and funding. This project had an expansive team of 30 students involved in its development and organization. Advisors are kept abreast of the team efforts but by no means are team leader and coordinator. This could be problematic since it requires a strong student leader(s) to keep the team focused and on schedule. As the travel date got closer, many of the final details, though completed, were rushed. Therefore, better time management and project schedule is required.

Another area of concern was communication with our hosts, FBU, prior to arrival.

Communication was done via email, which was sporadic and uneven. In fact, a week before departure, the host was caught off-guard, believing that the team was not coming. Though the travel did occur as originally planned and the team was welcomed, the panic caused by the miscommunication was apparent and could have potentially destroyed the moral of the team. In addition, developing a coordinated communication plan (contact numbers, how team can be reached, etc.) before departure was required and should be mandatory in these efforts.

Travel Coordination Issues

As noted earlier, the travel team consisted of the one faculty advisor and five students. Travel team selection was done via through a process developed and controlled by Tufts EWB student chapter; i.e, the faculty advisor's input was not sought nor offered. In addition, the travel team was never together for an extended amount of time prior to departure for Ecuador. Therefore, an opportunity to evaluate team dynamics (and prepare for issues of poor dynamics) could not be addresses. The team spent approximately 2 weeks in Ecuador, mostly at the Hacienda Picalqui, but also visited the community of Cristal in the Intag region of Ecuador and had short stays in Ecuador's capital of Quito at the beginning and end of the stay. Travel in Ecuador was done by taxi, buses, and rides in FBU vehicles. The most problematic mode of travel was by buses, which were often overcrowded and at started at stations known for an increase in the incidence of crime. Safety of the team was paramount. Remaining in a group and traveling with the Ecuadorian host proved to be the best crime prevention tactic.

On-Site Project Delivery

Overall, the team's efforts in Ecuador were outstanding. The students on the travel team had different majors - civil, environmental, and mechanical engineering as well as physic and community health. This diversity is necessary to allow the team to view each of the varied tasked through different, and important, lenses. And, it catalyzed the team to quickly coalesce into a cohesive and productive unit. Thus, the team was focused on the effort and accomplished more than anticipated. The group held nightly wrap-up meeting and were extremely focused on completing their assigned daily tasks. In addition, the team continually pushed the boundaries of what could be done while on the trip (e.g., connection to Escuela Politecnica Nacional). When faced with unexpected conditions, the team was not deterred. The reason for this success was the positive attitude of each team member and the genuine feeling that the team was working for a common cause of a better life for Ecuadorians.

Personal Reflections

As in most efforts by the Tufts EWB chapter, faculty advisors provide reviews of student implementation tactics and plans, but their major role is that of a travel chaperone. However, though the students provide the leadership and direction of the chapter and play significant roles in project development and delivery; advisor input should be sought during travel team selection. While the advisor's advice and counsel is sought during the project's development and implementation, his role during travel and project delivery is more of an experienced equal than as the all-responsible leader. However, for this project the role as travel safety officer was paramount. The daily mantra that "everyone makes it home" kept all team members aware of their surroundings.

Discussion – Lessons Learned

Budget and Fundraising

It is imperative that the students learn to fundraise. Being able to sell an idea to others is a skill worth developing. In general, these projects were supported internally with sponsorship by a major donor and grants from various Tufts programs and departments. It should be noted that living expenses are usually a small percentage of the total cost for a project. The major portion of the budget is for air travel to the project site.

Cultural Issues

Project efforts should be wary of unintentionally attempting to impose Western views on an established community to either cause social damage or delay acceptance of a solution the community had embraced. For example, in Gyatsa a conference with village leaders on how to proceed was carried out through translators and augmented by hand-gestures and pantomime. Talking with ordinary people who had no significant education in basic health issues, at least from a Western perspective, and learning how changes in lifestyle could influence their lives was of prime concern; therefore the team was not there to tell them what to do but rather to pass on skills that they could adapt to their needs.

Assessment of Student Learning and Development

With respect to direct evidence of student learning, the Tibet program supported a senior capstone design project in Mechanical Engineering. Presentations (oral and written) by team members provide direct assessment of student learning gained in doing the project. There are also papers^{5, 6} and a poster session at APHA¹³. The latrine and solar cooker designs for the Tibet project became senior theses, again providing documentation for measuring student learning. However, one of the more valuable skills that student development is leadership skills, both the students who make the trip and those who participated in on-campus activities. From start to finish, the students are the driving force behind the projects. For the EWB projects, the students conceived of a need for engineering students to have an opportunity to do a project with international service as a central focus. They perceived that interdisciplinary teams would be stronger when dealing with a foreign community. They organized themselves into an effective team where the individual leadership components could gel. They positioned themselves to take advantage of global service opportunities – connecting host country officials, non-government organization workers, and program sponsors. They did the planning and executed the technical designs. And they came through, under pressure, to surpass all expectations. So, while the faculty has been nurturing and supportive; it is the students that make it work.

In addition, though each project presented is in a very different region of the world, they all provided similar experiences regarding application of engineering skills to real problems with added the complexity of unfamiliar locations, cultures, and resources. Key challenges include changing conditions and compelling health and humanitarian issues. These challenges force students to operate “out of their comfort zone”, making students think about how they fit into a broader world on both professional and personal levels. The personal growth afforded by international service learning experience is likely to serve them well as future professionals and global citizens.

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