2006-1763: INTERDISCIPLINARY APPROACH TO A MULTI-PHASE ENGINEERING PROJECT FOR THE DEVELOPING COMMUNITY OF ARAYPALLPA, PERU

Vered Doctori Blass, University of California-Santa Barbara

Vered Doctori Blass is a graduate student at the Bren school of Environmental Science & Management at UCSB. She serves as the co-president of EWB-UCSB and as the Araypallpa, Peru project manager.

Mary Hong Loan Dinh, University of California-Santa Barbara

Mary Dinh is a Staff Engineer in the Mechanical Engineering Department at UCSB. She develops undergraduate laboratory courses. She also serves as the staff advisor for EWB-UCSB.

Interdisciplinary Approach to a Multi-Phase Engineering Project for the Developing Community of Araypallpa, Peru

Abstract

The student chapter of Engineers Without Borders at the University of California, Santa Barbara (EWB-UCSB) has been engaged in an engineering project with the community of Araypallpa, Peru since February 2004. Implemented in phases, the project included installation of a solar panel at the community's school, construction of a pilot slow sand filter to purify the community's domestic water supply, establishment of the community's health baseline, and assessment of future needs. The project team members come from a diverse background including electrical engineering, mechanical engineering, materials engineering, industrial engineering, chemical engineering, environmental science, geography, physics, biotechnology, film studies, and social anthropology. The team includes undergraduate and graduate students, professional mentors, and staff advisors. This paper presents an engineering service-learning project conducted by a multidisciplinary group of students and mentors on a solely volunteer basis. The main goals of the project, achievements, concepts incorporated, and lessons learned during the last two years are described. Funding, including budget and fundraising efforts, are also briefly described.

Introduction

Engineers Without Borders™ – USA (EWB-USA) is a non-profit organization established in 2000 to help developing areas worldwide with their engineering needs, while involving and training internationally responsible engineering students. EWB–USA projects involve the design and construction of water, waste-water, sanitation, energy, and shelter systems. These projects are initiated by, and completed with, contributions from the host community, which is trained to operate the systems independently without external assistance. The projects are conducted by groups of students under the supervision of faculty and professional engineering mentors. By involving students in every step of the process, the program maximizes their learning and awareness of the social, economic, environmental, political, ethical, and cultural impacts of engineering projects.

In October 2003, the EWB chapter at the University of California, Santa Barbara (EWB-UCSB) was established. The chapter consists of undergraduate and graduate students, professional mentors, and staff advisors. In addition to the project teams, the chapter has an executive committee that undertakes chapter development. Members may choose to be on a project team, serve as an officer on the executive committee, or do both. To date, the chapter has been involved in projects in Peru and Thailand. This paper presents EWB-UCSB's Araypallpa, Peru project as an example of a service-learning project conducted on a solely volunteer basis, using the principles of appropriate technology as a guide. A volunteer-based project may be a first step in introducing a service-learning component into the engineering program.

Project Description

EWB-UCSB has been working with the community of Araypallpa, Peru since February 2004. The community requested technical assistance from EWB-UCSB to implement sustainable engineering projects that would promote health, education, and community development. Araypallpa is a farming community of approximately 300 indigenous people located in the Andes Mountain of Peru, approximately 130 km south of Cusco. In August 2003, Juan Monterroso, community leader of Araypallpa, learned about Engineers Without Borders through Timoteo Martinez, who was born and raised in Araypallpa but now lives in the city of Arequipa. William Martinez, Timoteo's son, who helped to form EWB-UCSB, introduced the community needs to the chapter. Through William's personal connection to Araypallpa, a project was quickly established between EWB-UCSB and the community.

The vision for the project is to develop a long-term relationship with the partner community. The long-term relationship enables the EWB-UCSB team and the community to develop trust and understanding and allows for follow-up on the project progress and results. Thus far, two phases have been completed. In phase I, a team of six students from UCSB, a professional mentor, and a staff advisor traveled to Araypallpa in July 2004 to assess the community water and sanitation needs, to install a photovoltaic system to light two classrooms at the school, and administer a household survey on health, hygiene, and education. The group stayed for two weeks in the community.

From the assessment results, the goals of the project were defined:

1. Provide safe drinking water for the entire community.
2. Decrease intestinal illnesses in the community.
3. Provide affordable and clean energy for lighting to facilitate access to education and provide facilities for community meetings and social events in the evening hours.
4. Build capacity in the community through facilitating access to training and educational resources.
5. Establish a health baseline to evaluate project effectiveness.
6. Perform a water supply and demand assessment to understand water needs.
7. Develop a project model for other communities in the region.

In phase II, a team of ten students, a staff advisor, and a professional mentor traveled to Araypallpa in July 2005. As a first step in providing safe drinking water, the team installed a pilot slow sand filter to verify its effectiveness in Araypallpa's climate and in purifying Araypallpa's water source. The community was trained to perform routine maintenance and water quality testing. The team also assessed the water supply and demand and collected data to establish a health baseline. Additionally, the team met with community leaders to understand their priorities and needs for future projects in the region. This time, the team maintained a presence of two months in the community by staggering the stays of two groups. One member stayed for the entire two-month period to maintain communication and continuity between the two groups.

For phase III in 2006, the team plans to expand the water purifcation system, facilitate access to more educational resources in agriculture as requested by the community, establish a solid waste management program, and explore energy-saving lighting solutions.

Organization and Management

Project Team, Organization, and Control

The project members are diverse in their background and include undergraduate and graduate students from engineering (electrical engineering, mechanical engineering, materials engineering, industrial engineering, and chemical engineering), sciences (environmental science, geography, physics, and biology), social sciences (social anthropology), and arts (film studies). The team was divided into sub-teams to address the identified project goals. A project manager was appointed to coordinate recruitment, team organization, project scheduling, and logistics.

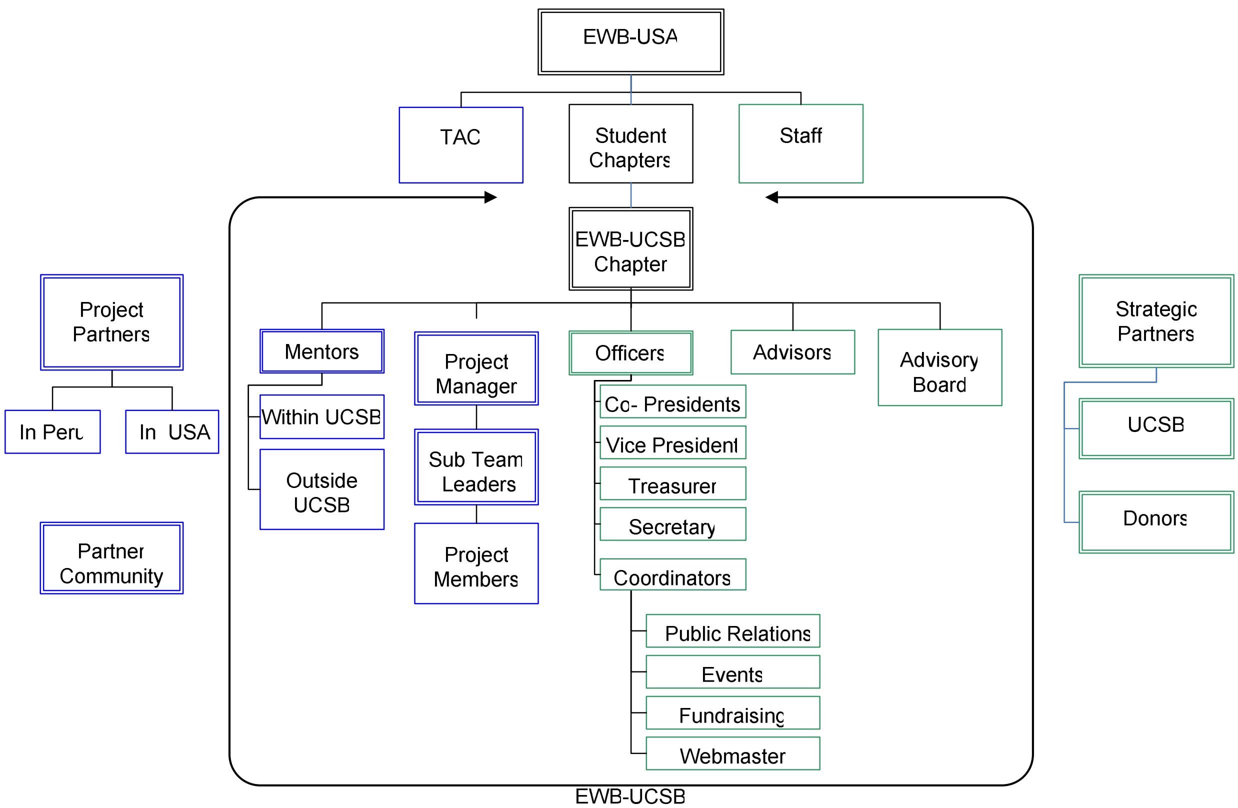

Figure 1: Chapter Structure

Figure 1 illustrates the structure of the chapter, project team, and external organizations that supported chapter and project team activities. The chapter consists of an executive committee and project teams. The executive committee supports chapter development and funding for projects. While the project members focus on working with the partner community and collaborating organizations, the executive committee works mainly with other UCSB institutions and donors. The chapter receives administrative and technical support from EWB-USA. In addition, the chapter assembled an Advisory Board for guidance in chapter development. The board currently consists of faculty members, professionals from the local community, and representatives of organizations such as Rotary.

As an EWB project, the project followed the EWB-USA project flow [1] which was established to ensure that projects comply to the highest engineering standards. Project proposals are reviewed and approved by EWB-USA for suitability of scope, partner community, student chapter resources, and advisors. Prior to any travel, project and travel plans are presented to EWB-USA TAC (Technical Advisory Committee) with enough time for additional information to be gathered or changes to be made. An Assessment Review is required two months prior to an assessment trip and a Design Review three months prior to an implementation trip. Once the trips are completed, a final report is submitted. A professional mentor or advisor is required for each project to guide the student team.

Collaboration

Chapter development activities included outreach and collaboration with organizations at UCSB, within the US, and within the countries of partner communities. Within UCSB, the chapter received support from several UCSB institutions including the College of Engineering and the International Center for Materials Research (ICMR). The College of Engineering provided the team with financial support, endorsement to work with its development team, and opportunities for networking. ICMR provided funding for student travel. This was a substantial support since travel to Peru was a large portion of the project budget. The project teams also received advising and hands-on training (e.g., plumbing workshops) from technical staff in the Mechanical Engineering and Electrical Engineering Departments.

Both the executive committee and the project team seek collaborations with organizations outside UCSB. The executive committee seeks contacts who might support chapter activities and development while the project teams look for more specific project support. Many professionals have enthusiastically donated their time to share their experience and expertise as guest speakers at general meetings or as technical mentors for project teams. For the water purification project, Blackburn and Associates[2] provided invaluable information on slow sand filtration systems.

The project team also sought project partners in Peru. The students researched and contacted local Peruvian governmental and non-governmental organizations. While in Peru, the students arranged meetings with organizations to introduce EWB-UCSB, exchange information, and learn about other organizations working in that region. Two Peruvian students in Cusco, hired as translators, during summer 2005 have requested to continue with the project in phase III on a voluntary basis after learning about the EWB mission.

The team established some important relationships that contributed to the development of strategies to increase community participation. The team contacted a visiting professor from the University of Mexico who has experience with communities similar to Araypallpa. Through discussions about the challenges and importance of community involvement, the team realized that a longer presence in the community was desirable and adjusted its plans to allow a two-month presence in Araypallpa in summer 2005. The team also visited Huacaria, a Peruvian community using the same filtration technology, with community members from Araypallpa so that they can see the system that is to be built in their community and meet community members who have been using that technology. Discussions with the director of House of the Children[3], the NGO working with the community of Huacaria, were valuable in learning about working with communities for long-term successful and common reasons for technology failures in 'developing' countries. The visit to Huacaria gave both the EWB team and the Araypallpiños more confidence in the approach taken.

To facilitate access to local resources, support, and information for the community, the team along with two community members visited organizations in Cusco including the Ministry of Health, international and local NGO's. The EWB-UCSB team is aware that it cannot serve all the needs of the community and that the community should not develop a dependence on EWB-UCSB for all its needs. Hence, one important role of the project team is to assist the community in locating and approaching local government and non-governmental organizations to solicit assistance for itself.

Logistics and Preparation

Students were involved in all activities and project aspects including research, design, purchasing, fundraising, and travel arrangements. All logistics preparation was done by the students, from equipment and materials research, ordering and purchasing, travel planning, and logistics in the community. Each sub-team was in charge of all of the above activities related to the sub-team assignment.

Prior to travel, the project team organized and attended hands-on workshops and training sessions to prepare for this unique cultural and educational experience. Workshops included technical training (plumbing, photovoltaic system installation, land surveying), health and sanitation workshop, cultural awareness, and security and safety awareness. The workshops were organized by the project manager and staff advisor.

Fundraising

The funds for the project were raised entirely by the chapter. The cost of the first phase of the project was $15,500 including materials, equipment, and travel. The cost of the second phase was close to $17,000 for all materials, equipment, and travel.

Fundraising was pursued through two avenues: (1) Project team members pursued smaller fundraising efforts, such as tostada sales, fundraisers in local restaurants, letter-writing campaigns to friends and family, and approaching departments and professors within UCSB. (2) A fundraising committee organized larger fundraising efforts such as applying for grants and awards and approaching local businesses and local organizations such as Rotary Clubs. In the first avenue, the project team members are actively involved. The second avenue is directed by a fundraising chair and usually done by a smaller management team.

Appropriate Technology and Sustainability as the Guiding Principles

In accordance with the EWB vision, the principles of appropriate technology and sustainable development were used to guide the project and shaped both the approach to the project as well as the technical design. Appropriate technology is described as being small scale, energy efficient, environmentally sound, labor-intensive, controlled by the local community, and simple enough to be maintained by the people using it. Sustainable development requires that resources are maintained while being used and that the project survives after the originators leave. For long-term success, an approach that encourages self-reliance, self-confidence, and responsibility in the community is essential[4].

Interdisciplinary approach

The team had constructed an interdisciplinary approach in order to address the social, environmental, economic, and engineering aspects. Geography students studying land use and water resources management led the water demand assessment. To provide the socio-cultural perspective, a social anthropology student was recruited to lead the future projects assessment to help ensure that all voices in the community were heard and to observe the human factors that affect project implementation. Film students were sought to document the project so that team members might see their project from someone else's perspective.

Environmental and Economic considerations

The engineering design is influenced by an environmental and economic perspective. The filter does not require or produce any toxic chemicals or expendables for regular operation. The photovoltaic system produces clean renewable energy. In approaching the water needs of the community, a water budget was performed wherein both the available supply and demand were considered. The maintenance cost for both the solar and the filtration system is minimal and affordable for the community.

Using locally available material enables the community to acquire replacement parts themselves instead of being dependent on a shipment from EWB-UCSB. Additionally, this reduces project costs by eliminating shipping fees as well as customs fees and taxes. Logistical problems associated with overseas shipping are also avoided. Two community members accompanied EWB-UCSB team members during the purchase of equipment and materials for the project so that they know where to buy replacement parts and are aware of the price of replacement parts.

Community Involvement

EWB-UCSB has been working with the community for the last two years and invested efforts in including the community in every step of the project to ensure community ownership of the project. Efforts were made during both the design and implementation phases. The team communicated design options, material needs, required space allocations, and maintenance and operations requirements to the community and solicited feedback before finalizing the water purification system design. The communication with the community during the design phase was coordinated thru a former team member residing in Cuzco.

During the implementation phase in Peru, efforts to promote community involvement included the visit to the site of House of the Children with community members as described in the collaboration section. As previously mentioned, the community members from Araypallpa took part in materials purchasing, including locating the suppliers and negotiating prices.

In the community, the involvement was high as well. Some community members participated by forming a water committee and filter maintenance committee. Others provided both skilled and unskilled labor in the construction of the slow sand filter. A critical aspect of the community involvement includes maintenance and operations training to build the community's capacity to maintain, operate, and troubleshoot the system on their own and to develop community ownership of the project. A key point for students to understand is the importance of investing time to develop an effective training strategy.

Lessons Learned

Important lessons were learned from the challenges encountered. Challenges and attempts to overcome them are presented here.

- Tight academic requirements for undergrad engineering students and the fast-paced quarter system presented time constraints in the planning and design phase. As reasonably expected, academic obligations took priority over volunteer activities. To overcome that, the project schedule was developed to allow for periods of high coursework demand (final exams, midterms) and breaks (spring break, holidays, etc) and the bulk of project work was scheduled during periods of low coursework demand.

- Coordination of a large team of students from different departments was difficult. Thus, smaller sub-teams were formed, allowing more flexibility in meeting coordination. Sub-teams managed their own tasks and timeline. A helpful tool for efficient project management was establishment of a project management task file for each sub-team and the project as a whole.

- Fundraising is always a challenge, especially funding for travel costs since donors tend to think that this may encourage students to participate for the "free vacation." University organizations that promote international exchanges (ICMR in our case) may be more willing to fund student travel expenses. Money raised from other donors may then be dedicated for equipment and supplies. Also, sponsoring bi-weekly tostada sales demonstrated student dedication to the project and helped to garner support.

- As in any field project, last minute changes and lack of resources were encountered. Flexibility and improvising were required. Allowing extra time for the unexpected and being prepared for a variety of situations in the field is wise.

- Water and sanitation are critical components of the community's daily life. A lack of awareness of critical issues may lead to a poor design that places the community in a more precarious or even dangerous situation. In order to minimize the risk, the team sought advice from experts in slow sand filtration and people with experience in development work. People who opposed or challenged the project brought students' attention to aspects they were not aware. The team heeded these concerns and developed approaches to address them.

- Most students were usually interested in the design tasks, not the administrative tasks. Interest in administrative roles was promoted by emphasizing the skills that would be gained and important contributions that would be made. Providing tools like project scheduling and fundraising resources and workshops assisted team leaders in managing their responsibilities.

- Human factors, including community ownership, must be addressed if the project is to be sustainable. Although the construction stage takes only a few days, community ownership is a process that starts from the inception of the project and continues beyond completion of construction. To bring awareness to the social and cultural aspects and properly address them, a multi-disciplinary team was recruited for this engineering design project, including a social anthropology student.

- An understanding of daily life in the community, insight into the internal management and decision-making process of the community, and follow-up on training all required a longer presence in the community. Travel schedules of two groups were staggered to allow a two-month presence in the community while still accommodating students with summer internships or summer classes. Communication between groups coming and going must be well coordinated. Having a few people who stay the entire period can greatly facilitate continuity and communication.

- On long term projects, continuity can be a problem as students graduate. Advisors serve an important role in maintaining continuity from year to year.

Conclusion

The enthusiasm and dedication of the students were striking and noted by the university community. Even without the tangible rewards of grades, credits, or pay, the students demonstrated impressive initiative and commitment to realize the project. In conducting the Peru project as a volunteer-based project, the main advantages included the following:

- Students have the opportunity to remain with the project over several academic years which helps maintain continuity in the project. Of the thirteen students who have participated in the Araypallpa, Peru project, nine have returned for the subsequent phase.

- Participation of students from other academic fields, such as social sciences or environmental studies, is easily facilitated, allowing for a multi-disciplinary team and interdisciplinary approach. A multi-disciplinary team allows the environmental, economical, and socio-cultural factors to be more fully investigated. Engineering students gain experience in working with students from other academic disciplines and the opportunity to incorporate the different perspectives into their design.

Of course, there are trade-offs. The volunteer-based project presented the following drawbacks:

- In starting an organization such as Engineers Without Borders, a large work load ranging from technical design to fundraising and chapter development usually falls on a relatively small group of volunteers. The work load can be overwhelming for even the most committed group of volunteers.

- Project progress tends not to be steady, as members may put project work on hold for academic or work obligations.

Improvements that could be made include addressing the above drawbacks. Additionally, a project evaluation process should be developed. Although student reflection was encouraged through journaling and group discussions, a formal process for student reflection could be incorporated. Finally, a language requirement would improve communication between the team and the partner community, thereby enhancing the exchange of information and the collaborative relationship.

At UCSB where a service-learning program is not available for engineering students, the Araypallpa, Peru project provided a way for students to engage in service-learning projects, learn about appropriate technology and sustainability, work on a multi-disciplinary team, and learn how engineering skills can be used to serve the needs of the global community. In addition, students developed a set of skills that typical classroom education does not provide. A volunteer-based program may be especially useful as a mechanism for service-learning since the undergraduate engineering curriculum is normally very full, or it may be a first-step in introducing service-learning into the engineering program.

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