AC 2008-785: KEY EXPERIENCES IN DEVELOPING A SUSTAINABLE WATER DISTRIBUTION AND FILTRATION PROJECT IN RURAL HONDURAS: A NEW PARADIGM IN "SERVICE LEARNING"

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Abstract

The University of Southern California chapter of "Engineers Without Borders" (EWB-USC) was formed in the fall of 2006. Within six months of its charter approval, the chapter obtained, assessed, and began raising funds for a water project in the village of La Estanzuela, Honduras. Since the village has no electricity, the design process began with a ram-pump to transport water from a nearby waterfall to a tank at the center of the village. A number of tasks were defined for the assessment trip, which was taken in March 2007. Technical measurements included terrain GPS samples, river flow rates and multiple water samplings and testing. A preliminary system design was formulated, and a community health survey was administered. The data are being analyzed to finalize system design and establish baseline health and water quality measurements. Planning for a final assessment trip in March of 2008 has also been finalized. EWB-USC is partnering this effort with a number of humanitarian organizations, and the International Rotary Organization's "Decade of Water Improvement" to provide some of the supplies and equipments for this project.

This paper highlights the key experiences in organizational development, project funding, trip planning, assessment trip and lays out a five-year project plan for our future efforts. The hope is that through exposure to these experiences, other newly formed EWB student organizations will plan for their activities in a more efficient and responsive way.

1. Laying the Foundation

The programmatic goal of EWB-USC is to provide students with a life changing experience that propels them on a professional trajectory of social entrepreneurialism, activism and sustainable technological development. Fostering the development of such a unique experience within the traditional engineering education paradigm has been a trying process. The many challenges have ranged from organizational, to technical, and even interpersonal. Yet, the outcomes so far have been greatly rewarding both educationally and professionally, and have shown great promise for accomplishing the goals of the project.

2. Background

Students Nate Houk, Kyle Siegel, Leah Glynn, and Meghan Grey founded the University of Southern California's chapter of "Engineers Without Borders" (EWB-USC) in the fall of 2006. Initial interest for EWB-USC was modest and only four students met regularly with the guidance of the faculty advisor. Group meetings were entirely voluntary, as it is required by the USC's guidelines for extracurricular student organizations. From a group membership perspective, the initial team included only one environmental engineer and no civil engineers – the very students whose expertise were closely mirrored by the project they later selected. While there was a fear of relative lack of broad-based technical expertise, the team was enthusiastic and dedicated to the spirit of EWB. The team went through a series of initial application submission and approval processes at USC and obtained an official project from the EWB-USA national office. The two options were either applying for an "open" project on the EWB-USA website or finding an independent project and go through the national approval process. Open projects listed on the EWB-USA website are mostly submitted by non-governmental organizations (NGOs) or individuals in the developing world, and posted to the website if accepted by a review team. Individual EWB-USA chapters can then apply for these projects[1]. A limited list at the time was made up of projects that were too extensive and complicated for the new group to comfortably pursue alone. Thus, the group decided to find its own project. After a few weeks of searching, an individual with a project in a rural Honduran community in mind approached EWB-USC with an offer that was accepted and successfully applied for through EWB-USA headquarters.

3. Community and Project Description

A Peace Corps volunteer acted as the on-site contact for the project team. Based on the original project description filled, the team felt that it had the needed basic information about the project and began exploring and expanding its information base. This is the first lesson that was learned by the team: *real world problems do not come with complete problem statements and data bases to hint at an easy solution*. The team was basically told that a group of rural Honduran villagers were in need of clean drinking water, and that the villagers suffered from health problems as a direct result of drinking contaminated water. There was no mention of any health metrics, potential nearby water supplies, or even any possible approaches to solve this problem. Only after traveling to Honduras for the first time (see "Assessment Trip"), could the team fully realize the full extent and dimensions of the task at hand.

The town of La Estanzuela is located in the La Paz district of Honduras, which is itself in the southwestern region of the country, bordering El Salvador. A short drive from the municipal capital of Marcala on concrete highway and bumpy, dusty dirt roads that wind through forested hills and valleys brings one to the relatively decentralized village of La Estanzuela. A collection of 50+ small, two to three room buildings occupy around three hundred people, the majority of whom are indigenous Lenca Indians. Some homes have rudimentary floors, others simply dirt; many homes have basic latrines, but without any plumbing. There is no connection to the country's electrical grid. Two small schoolhouses overflow with students (through early high school) because children from smaller neighboring villages walk – some of them several kilometers daily – to La Estanzuela for their education. The limited space means that some classes must be held outside. A central community building consisting of a large room, a pair of small general stores, and a dirt soccer field flanked by bare metal goalposts complete the infrastructure for this village.

A water transport system was built in La Estanzuela in the past, but is now barely functional. The system draws water through a gravity-fed system from a lagoon several kilometers away, and provides an intermittent supply of visibly yellow and fecal contaminated water (see the picture below). This water collects in a ten thousand gallon tank on a hill that feeds pipes to faucets near the homes in the village below. This set up provides an insufficient volume of water that is not different in quality than the river water collected by the villagers with buckets and bottles. Acute diarrhea is the most pervasive health problem due to water quality, although no formal medical records are kept in the village due to lack of a modern health facility. Women and children frequently spend time – often an hour a day or more – collecting and carrying water.

The people themselves are friendly and helpful, although they have grown wary of outsiders who have so often promised to help the community, but have rarely followed their words with action. The vast majority of the villagers are farmers, and a few people operate small businesses out of their homes or a communally owned store. There is also an attempt to establish a fishpond for aquaculture, and to furnish a pair of small cabins in the scenic river canyon nearby to attract tourists. Of great relevance to the water project is the fact that La Estanzuela has elected a "water board" to oversee the use and maintenance of their current water supply/transport system. Currently there is a small fee for using this contaminated water. The water board is an important partner for EWB-USC (see "Community Partnership) in the attempt to provide a sustainable solution to the current water quality and availability problem.

4. Assessment Trip

In this section, we provide a narrative that explains the key insights into the trip experiences based on the specific events during the assessment trip. The WB-USC's first assessment trip was in March of 2007. Nine students and a mentor (a professional engineer from the Los Angeles Chapter of EWB) were selected to travel to La Estanzuela. One advantage was that one team member was a native Honduran, and all but one of the remainder had studied Spanish in high school to varying degrees of proficiency. Our major roadblock, however, was the inability of the team to secure complete external funding in time to meet the deadlines for this first trip, scheduled during the spring break. The week's travel was organized with a financial support from the school and the students paying for a substantial portion of the costs themselves.

The team met the Peace Corps volunteer at the Honduran airport and took buses and a borrowed pickup to Marcala, the city nearest to La Estanzuela. Every day the project team would drive into La Estanzuela to meet with members of the community and to go off and perform the various tasks that were assigned: mapping the existing water distribution system, recording the GPS coordinates of important locations, measuring the river flow rates, performing water quality testing at multiple locations, staking the delivery routes, measuring preliminary topographical indicators for the proposed water pipeline, and consulting the community members thoroughly for their opinions on their needs as well as conducting a preliminary health survey.

The notion of building a relationship with the community turned out to be as important to the success of the assessment trip as the technical work. Through conversations with the community, the team members learned that multiple humanitarian organizations had been to La Estanzuela promising to help in one way or another and rarely lived up to their word. This fact became apparent when the team saw a large map made of papers brought by other groups, the backs of which were the surveys questionnaires. This skeptic view of the community was the first obstacle needed addressing before any progress could be made.

This skepticism was partly addressed by talking to the community in a general meeting. In this meeting, the idea of EWB-USC subsidizing the purchase of a filter for each family was suggested. This decision was made with the community leaders on the basis that the effective temporary filters would be used until a long-term water treatment solution (the official project) could be put in place. After an affordable subsidization was agreed upon, the community became excited at the prospect of this short-term assisted solution to their water quality problem. Before traveling, the team was in contact with an organization called "Potters for Peace" – a nonprofit organization that sets up terra cotta water filter manufacturing facilities in the developing world[2]. The team contacted a local Honduran manufacturer, Maximo Saldago, whose shop was only a few hours drive away. An order was placed for fifty filters on short notice with Maximo, which they managed to fill in time and deliver to the team in Marcala. EWB-USC then arranged a second meeting with the assembled community during which a native speaking team member thoroughly explained the use and maintenance of the filters to the point where the community members could explain the entire process themselves. Within a day, each family purchased a filter (see the picture at right). The attitude of the villagers turned even more positive when they saw a gesture of temporary help from the visiting team.

A pair of meetings with two Honduran Rotary clubs was also conducted. EWB-USC had planned to work with "Rotary International" on a matching grant to fund the project, and securing the partnership of a Rotary club in Honduras was vital to that process (see, "Partnerships" below). Both meetings went well, and a verbal commitment of support was obtained from the Rotary club in Marcala.

5. Partnerships

It is important to note that EWB-USC's activities center around working with the community. La Estanzuela's water board and the community members possessed valuable local information and personal insight into the conditions and issues that affect their lives and their village, as well as the physical means required to build the project. This valuable information can and will be used to ensure successful completion of the project, as well as its technical, economic, social, and environmental sustainability. *It is also vital to ensure that whatever project is being worked on, present or future, is congruent with the community's self-identified wants and needs.* The literature in quality engineering is full of references to the fact that the user of a system must be an integral and an indispensible component in the decision-making process[3]. In this respect, EWB-USC functions predominantly as a technical planner, system integrator, and financial fundraiser (see "Partnering Organizations" and "Initial Design Preparation").

5.1 Participatory Model

From the start, we became aware that the any approach to solving the problem should be performed cooperatively; as opposed to EWB-USC defining La Estanzuela's "problem", doing the work, and imposing the "solution" without further consultation[4]. For example, the villagers served as guides for the shortest, most direct path that the new pipeline would take through the forest – cutting stakes and marking the path as a survey team moved through the woods.

A specific situation encountered during the 2007 assessment trip illustrates the potential risk in not following a thorough participatory model. While visiting another village, a team member met with the local schoolteacher and asked if the school would benefit from having electricity. The teacher emphatically supported the notion, and after further conversation it became clear that the teacher wanted to power a coffee maker for her morning drink. Primarily, without that student's diligence in asking further questions about that teacher's request, we would have most likely left with the notion that providing power to that school was a good candidate for a future project, with the expectation that electricity would be used for more practical applications such as lights or a computer.

Further discussions with the community indicated that the water table could be high in this area, causing pit latrines contaminate groundwater supplies during the rainy seasons. In these situations, the villagers were forced to drink directly from the contaminated river. Thus, a thorough participatory method of community decision-making will bring to light any needs, such as those outlined above, that would not necessarily be elucidated by narrowly focused inquiry.

Equally importantly, the community discussions brought to light that there will be a demand for manual labor and raw materials during the final construction of the system itself. It was decided that the intensive work such as excavation and necessary pipeline trenching will also be the responsibility of the villagers. Materials such as stone, gravel, sand, and wood – all locally available - will be gathered and provided by the community. Not only is this work far more than a small group of students could accomplish in a few weeks time, but it is hoped that this will help to create a sense of investment, collective ownership, and above all responsibility to maintain the system in operable conditions.

5.2 Partnering Organizations

EWB-USC's initial success can be attributed in part to its cooperation with other groups and organizations, mainly humanitarian NGOs. The United States Peace Corps, several Rotary Clubs, and Potters for Peace, are three resources that have been utilized to simultaneously inform, accelerate, and enable the process. Eric Harrison, a Peace Corps volunteer and in-country liaison has been instrumental in providing pertinent information on request, as well as acting as an outstanding facilitator during the initial assessment. EWB-USC also relied on the project material and equipment costs coming from the grant process through the Rotary International: Rotary Foundation[5], with primary sponsorship from the Rotary club in Century City, Los Angeles[6]. EWB-USC anticipates working with a number of other organizations, both in the U.S. and Honduras as the project progresses. Lastly, Potters for Peace has facilitated the tangible show of commitment to the people of La Estanzuela (see, Assessment Trip, above).

6. Project Sustainability

The three pillars of sustainability for the La Estanzuela water supply and treatment project are technical, economic, and environmental. In short, sustainability for EWB-USC projects comes down to the ability of the completed project to be as simple and long lasting as possible while working with minimal maintenance for the village community. In addition, these sustainability criteria will be a useful tool in feasibility studies when narrowing down the list of appropriate solutions. For example, a diesel-powered water pumping system is of little use if the community cannot afford constant deliveries of fuel.

6.1 Technical Sustainability

Any implementation must ensure that the community knows how the water pumping and treatment system works and how to maintain the system's operation. Basic repair knowledge needs to be passed on, and as a backup, access to a local technician is necessary in the event that any repairs become necessary. In this instance, several members of the La Estanzuela water board will be present during all phases of construction so that the system's workings can be thoroughly explained and documented in their own easy-to-understand language.

6.2 Economic Sustainability

Economic sustainability is achieved by ensuring that the community can finance the operation of the system both initially and throughout its life[7]. One option considered was to install a point power source with alternative energy source (solar, wind, or hydraulically powered system). These systems do have varying initial costs, as well as maintenance costs, which are important factors for the final selection. At the time of writing, system design has not yet been finalized, so a more detailed economic analysis of these options will be presented in the future.

6.3 Social Sustainability

Social sustainability, as used herein, means that the chosen solution can be effectively operated and maintained by the project beneficiaries – as well as ensuring that the final outcome is concurrent with the community's wants and needs. Community members will collaborate with the design team to establish the locations of critical system components, and there will be continuous contacts between the team and the community leaders, as well as the President and Vice President of the community's Water Board. The Peace Corps volunteer has offered to act as a correspondent for the team, and to hold community meetings to facilitate planning and management of the project.

At all times, the community's input and preference will be taken into consideration while discussing future plans such as wastewater and potential sanitation disposal. During the project implementation, the community will offer local materials such as sand, gravel, rocks, and wood. The villagers will also be responsible for all labor associated with construction, and will have plumbers trained to maintain the system. Verbal and pictorial instruction and education on the operation, management and maintenance of their system will be provided.

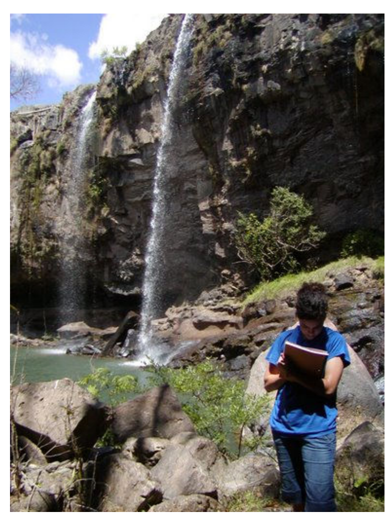
6.4 Environmental Sustainability

Environmentally, sustainability encompasses more than a technology simply being "green" in the traditional zero-pollution sense. For example, both wind and solar powered pumping systems are environmentally advantageous. However, they are sensitive to poor wind or sunshine conditions and impair or cease the energy flow to the pump altogether.

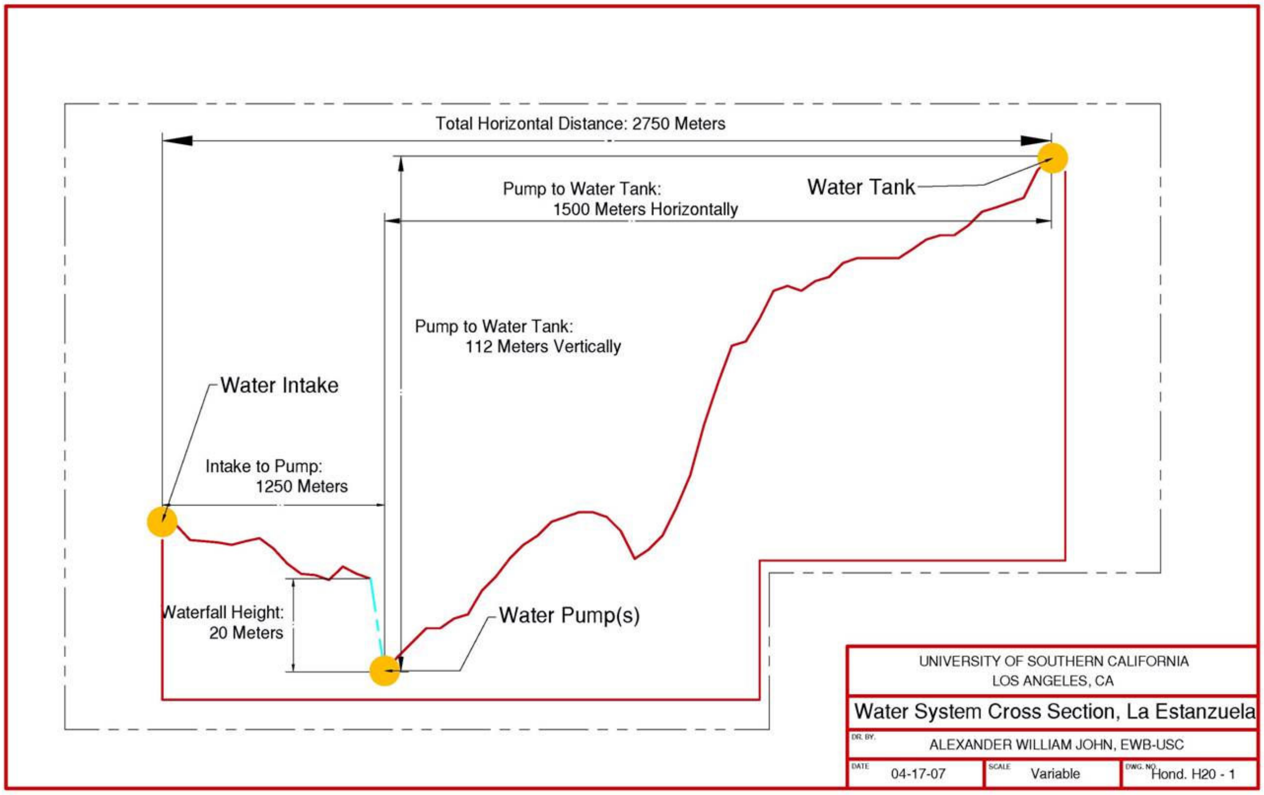
During the assessment trip, it was determined that the general climate patterns of the project site are not suitable for the efficient implementation of these technologies at the scale required. Water wheels and rams are also zero pollution, and entirely mechanically powered. They do however require either specific topographic or elevation conditions to be met for efficient operation.

7. Initial Design Preparation

After the travel team returned in late March 2007, the process of data analysis and initial system design began. The serious work began again in earnest at the beginning of the 2007-2008 school-year (student-based service learning projects such as EWB-USC are sensitive to the general academic schedule; schoolwork and summer jobs/internships can establish themselves as priorities). The project team had lost a few members due to graduation, and picked up some new students, as well as a professional water resource engineer. Design work was split between committees, each responsible for a separate aspect of the system design. Within two months, a preliminary system design framework was completed.



The initial system plan resulting from the first assessment trip (and subsequent information provided by Eric Harrison) entails a hydro powered mechanical water pumping system stationed at a waterfall on a nearby river (see the picture at right). The water will be collected upstream from the waterfall where the water is cleaner, the sediments will be reduced before entering the pumping system, from where the water will be propelled approximately 1.5km horizontally and 100m vertically into a pre-existing water tank (see the graph below). The 10,000 gallon tank will then have its chlorination tablet system retrofitted so that it can deliver clean water through the existing distribution network in the village.



It was also determined that another assessment trip is necessary to collect more design-relevant data and engage in more community participation for the final design success. In that discussion, different options will be considered, along with the respective labor and materials costs involved. Returning for another assessment trip will also allow more students to be exposed to the project, as all but two of the original travel team will have graduated by the end of the 2007-2008 academic year. Additional data will be collected, especially topographical information around the waterfall where the pumping system will be installed. Also, iterative health and water quality metrics can be obtained. This iterative quality assessment is a necessary part of the project success based on future health surveys – a determinant of success outcome.

One final note on the technical/organizational linkages needed to move the project forward: *as the number of the students began to increase and the system design complexity became more apparent, the group felt the need to centrally organize communications and design documentations*[8]. After some searching and discussions with experts, the team decided to use a web-based communication and project management tool called "BaseCamp"[9]. This automated tool reduced the communication overhead and helped maintain our system design integrity. The tool also provided a secure place to archive all of our discussions and plans in an organized fashion.

7.1 Potential Impacts to the Physical Environment

As a part of the sustainability effort, the potential impact that the project could have on the physical environment must be considered. The following are some concerns that need to be addressed during the formulation of the implementation plan:

- Pumping water to the village will decrease the stream flow. While it is assumed that the amount of water removed will be negligible compared to the stream flow, the team should investigate this flow reduction. The likelihood of such an impact will be determined through observations and discussions with village leaders.
- By providing more water to the villagers, there is a possibility of overloading the current wastewater system in the village, requiring further need for wastewater treatment[10] (Mara, 2004). A system will be implemented to manage this flow, which will be monitored in the future by the local Peace Corps volunteer and by observations during subsequent trips.
- There is a possibility of soil erosion in the areas where the pipelines will be laid. This will also be monitored by the local Peace Corps volunteer and by observations during subsequent trips.

7.2 Team Training and Technical Capabilities

EWB-USC requires training of its students for possible engagement in the technical design. The team has completed the following training to improve their technical capabilities:

- Drafting (AutoCAD), 3D modeling (Solid Edge)
- PVC (polyvinyl chloride) pipe assembly
- Water and waste water treatment design
- Hydraulics design and assembly (EWB-USA regional workshop)

Limited training has been undertaken in the following areas to prepare students for the on-site assessment trips:

- Surveying
- GPS
- Spanish language lessons and ethnographic methods
- Safety and basic first aid skills

8. Evaluation Metrics

The technical adequacy and success of this project will be determined by comparing the amount of potable water available and the time spent in collecting water, both before and after the new system is implemented. The quantitative health success of this project will be evaluated by comparing the water quality of stream and filtered water after implementation, and by performing community health surveys in Spanish before and after implementation. The project has not been completed, so no success evaluation metrics can yet be reported at the time.

8.1 Economic Impact

The economic effects of this project on the community will be coordinated through the community's Water Board, which will collect water payments, maintain, and administer the system. There will be a significant initial cost (in both labor and materials) to the community. However, the time that individuals spend collecting water will instead be available for use towards accomplishing other economically productive activities – an impact often felt disproportionately among children[11].

8.2 Health Impact

The project team conducted a baseline health assessment during the initial assessment trip, and will continue to measure community health statistics through the project process. The community's health effects will be measured by monitoring the occurrence of gastro-intestinal sicknesses (Cholera, Dysentery, Acute Diarrhea, etc.), before and after implementation of the project. The health assessment will be conducted through personal interviews of the community, and follow up interviews performed by students on subsequent trips in the Marcala region. Efforts will be made in employing a school teacher or community doctor to perform regular health surveys to determine the health benefit of providing potable water to this community. A more quantitative health-related metric will also be obtained through iterative water testing data.

9. Five-Year Plan

While one phase of a project is being designed and built, it is important to start discussing further plans for subsequent phases of development. This process is best undertaken as a participatory design process in which the community members have ultimate control over their choice, with guiding input and advice from EWB-USC engineers and consultants. For example, one can present a series of feasible options to the community and ask the assembled community members to collectively rank the importance of the prospective projects against the others until a relative hierarchy is reached. This model mirrors the PAPPA (Policy Analysis for Participatory Poverty Alleviation) process[4]. By this method two important outcomes will have been reached: the community will have discussed and come to a consensus on their collective goals for the near future, and the goal of the next phase of community development will have emerged in a cooperative and constructive way.

Based on this approach, EWB-USC has agreed to work with the community of La Estanzuela for a period of 3-5 years on a series of sustainable engineering projects designed to help the villagers improve their quality of life in various ways. At the time of writing, the planning for the second assessment trip in March of 2008 is nearly complete, leading to the first implementation trip in summer or winter of 2008. Two implementation trips and a contingency plan for the third one to complete the water project are envisioned, all occurring in the academic years 2008-10. The last implementation work will include a technical training effort to educate the community on the operation and maintenance of the entire system. This training will include identifying and negotiating with the suppliers on parts and assembly, in addition to document delivery in Spanish on any new changes to the system. The next phase of the project is the evaluation of the outcomes. The tools and the approaches to this evaluation are being considered with a professor of cultural studies at USC. Her expertise is in the impact of language and cultural variables on the use of technology. Instruments for this evaluation will be designed in parallel and administered during the last implementation trip.

It is interesting to note that as the campus community is becoming more aware of our efforts, and more students joined EWB-USC, the group received a number of requests to begin another project. EWB-USC is undertaking the planning for another water project in a nearby village of Corral de Piedras. In addition, this past semester, a small number of students have started a new effort to design and install solar panels for these villages. We have been able to secure and test a small solar electric system to run a laptop for the village schoolhouse. This test-bed has been used during the campus events to attract other students to the EWB-USC. Decisions about the coordination trip to begin considering the installation of a solar energy system in La Estanzuela is not yet finalized.

10. Service Learning

Students in today's world are yearning to help solve complex environmental and geopolitical issues that involve poverty, disease, and social injustice. Unfortunately not enough students have access to the key skills and resources required for working in the international development setting other than through participation in programs such as the Peace Corps (which requires a college degree) or a limited number of study abroad programs. While these experiences are valuable and helpful to communities around the world, they offer little exposure to the science behind the effort, nor the role of technical innovation and importance of entrepreneurialism and the environmental protection in the development process. While academic curricula may teach students that 'community-based' projects that are 'bottom-up' and emphasize 'sustainability' are ideal, they don't teach students *how* to actually achieve those objectives, let alone educate students about the 'nuts and bolts' of how an international development organization such as "Engineers Without Borders" are run. EWB-USC will empower students with both the knowledge of international environmental and social problems while simultaneously providing the comprehensive technical skills training required for solving those problems through an intensive project-based service learning program – *a new service learning paradigm*.

The authors believe that the environment at USC is ripe for a shift into this new paradigm. Discussions with the Deans and program directors have indicated that there might be a potential to incorporate this model into the Viterbi School of Engineering under "The Klein Institute for Undergraduate Engineering Life" (KIUEL). This institute has been recently established to provide Viterbi undergraduates a variety of personal and professional activities that will enhance undergraduate engineering student life experiences outside the classroom. The three building blocks of KIUEL focus on leadership**,** cross-disciplinary activities and service learning and globalization**.** The mission of KIUEL is to support and enhance already existing student development programs in the school, as well as to create and implement new initiatives that contribute to the holistic experience of the Viterbi undergraduates[12]. As mentioned before, real problems of the developing world require multidisciplinary approaches from across the campus units. Thus, further discussions are under way to bring this to the attention of the rest of the university through the provost's office. Ideally, students from across the campus will be involved in what is being termed as *"Trojans Without Borders."*

EWB-USC also realizes that no effort of this magnitude could sustain itself over a long term if it is not *institutionalized* within the fabric of the university's organizational structure. At the time of writing, a proposal has been submitted to the USC Provost's Fund for Undergraduate Instruction and Training to explore the possibility of integrating this effort into the curriculum of the engineering school, with the objective of expanding this service learning to other campus units.

11. Lessons Learned

The following is a list of lessons learned from the key experiences EWB-USC has had in the first phase of the La Estanzuela water project:

- Real world problems do not come with complete problem statements and data bases to hint at an easy solution.
- It is vital to ensure that whatever project is being worked on, present or future, is congruent with the community's self-identified wants and needs.
- The people you are 'helping' should not be underestimated. They have valuable knowledge of their lives and locality, and are a valuable resource.
- Some of the most important contacts – and therefore resources – are obtained through surprisingly informal measures. Who you know can oftentimes be more important than what you know.
- As the size of a project team and system design complexity increase, centralized organization of communications and design documentations becomes increasingly important.
- Project planning is an important part of the overall activities. Use project planning tools and expect delays in both task completion time and funding.
- New team members will not stay around for long if they are not given an immediate project-related task to work on; ideally this is undertaken jointly with an existing team member to help them navigate through the current tasks.
- Compile assessment trip data together in one 'master file' as soon as the team returns home. Data can be lost or scattered as individuals move and/or graduate.

12. Acknowledgements

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