2006-1188: PROVIDING ENGINEERING STUDENTS A GLOBAL PERSPECTIVE THROUGH A PROJECT FOR DEVELOPING COMMUNITIES – LESSONS LEARNED AT THE UNIVERSITY OF HARTFORD

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Providing Engineering Students a Global Perspective through a Project for Developing Communities – Lessons Learned at the University of Hartford

Abstract

The University of Hartford strives to offer its students a complete education, one that will prepare them for the challenges of the global community of the 21st century. To help meet this mission, the engineering faculty has supported a multidiscipline group of students' initiative to perform an extracurricular design project for a developing community by including relevant topics in their courses and through a series of special seminars. The design project that was selected by a team of University of Hartford and Wesleyan University students was to assist Abheyur village, which is located about 30 km from New Delhi, India, with some severe potable water issues. Assessment by faculty and students of this extracurricular approach with course support indicated that a more structured approach was required. The current approach only provided the students with the minimal technical background in sustainability and appropriate technologies, and did not at all address the social, political, and business aspects of how their proposed solution would affect the lives of the people living in the village. The challenge facing the faculty was deciding if this should be an additional required course, replacing an existing required course, modifying an existing course, or an elective course. Also, interested faculty and students discussed at what level (i.e., freshman, sophomore, junior, or senior year) the course should be included. From this assessment process, it was decided to have one section of the required interdisciplinary sophomore design course have a "design for developing community" theme. One of the concerns about offering a course such as this is the funding needed so that all 10 – 15 students have the opportunity to travel to the village and implement their design and learn about all the "on-location" issues that arise, which can not be duplicated in the classroom. To help offset part of this cost and to get the needed involvement of practicing engineers into the course, the University of Hartford is fortunate to have been included in Pratt & Whitney's business plan to include a pilot Engineers Without Borders[1] project as part of their philanthropy program. While there are several organizations that are involved in design for developing communities projects, Pratt & Whitney has selected Engineers Without Borders because of the assessment and implementation process it has in place, which they feel has led to the success of numerous projects. To take advantage of this opportunity, University of Hartford students and faculty are working toward becoming an official student chapter and having the Abheyur Village accepted as an official project. It is anticipated that the "Engineering for Developing Communities" sophomore design course will be first offered in spring 2007.

Introduction

The University of Hartford's mission statement emphasizes that taking an active role in the community is an important element of a student's preparation for a lifetime of learning and personal and professional success. Furthermore, the University of Hartford also strives to offer its students a complete education, one that will prepare them for the challenges of the global community of the 21st century[2]. The element of "taking an active role in the community" has

been incorporated into the engineering curriculum through service learning projects that both support the course outcomes and benefit the community. Numerous examples of these type of research and design projects have been described in previous ASEE conference papers and assessment of the service learning projects by community sponsors, faculty, alumni, and students has been very positive.[3,4,5] However, most of the projects focused on the Greater Hartford area and do not give the students a perspective of the global challenges they will face throughout their engineering career.

To meet the goal of providing our students with an opportunity to work on a design project for a developing community, several alternatives were considered. Initially, it was decided that the best approach for an engineering school of our small size (approximately 350 undergraduate engineering students) was to support students' interest in this area by having course work in their existing classes support their extracurricular design project. While a new course on Engineering for Developing Communities was considered, it was concluded that is was not feasible to add a required course to the curriculum because of the pressure to reduce the total credit hours so that students can complete their engineering degree in four years. Also, the elimination of a required course is difficult at this time because all of the required courses that have survived recent "course reduction" exercises are considered "essential" by at least some of the faculty. Finally, the faculty was not in favor of eliminating another professional elective because it was felt that student should be able to select at least three courses that meet their professional needs. (The civil engineering curricula and description of the courses can be found at http://uhaweb.hartford.edu/CEE.) In addition to curriculum issues, the other major concern was that a large time commitment would be required to obtain external funding so that students would have the opportunity to implement their design, and more importantly, obtain the learning experience associated with have to deal with "on-location" issues that can not be duplicated in the classroom. While the initial enthusiasm for the course might provide the incentive to obtain outside funding for the first two or three years, it was felt that it would be difficult to sustain an Engineering for Developing Communities course on a long term basis.

This paper will discuss the advantages and disadvantages of our initial approach of supporting an extracurricular project with work from existing courses and seminars, and how we came to the decision to provide a more structured approach in the future for students interested in obtaining a "global" experience.

Student's Desire to Get Involved in an Engineering for Developing Community Project

An interdisciplinary group of engineering students from the University of Hartford have taken the initiative to work on an engineering project for a developing community. The project that the students selected was presented to them by a group of Wesleyan University students from their community service / service learning center. Through a relative, one of the Wesleyan students was aware of the urgent water problems in the village of Abheypur, India. The Wesleyan students were anxious to help the village and were cognizant of the many cultural issues related to their water problems. However, there were several technical issues concerning broken pumps, limited access to electricity, and declining ground water levels that they did not have the background to address properly. Therefore, the University of Hartford and Wesleyan University students decided to work together as a team in developing and implementing a sustainable

solution to one aspect of the village's water problems. The following is a summary of the project. The majority of the information presented is from email correspondences between a Wesleyan student and Navjyoti, an NGO in New Delhi, India.

Potable Water Challenges Facing Abheypur Village, India

Project Desicription
Abheyur village is in the eastern part of Gurgaon district in the state of Haryana, about 30 km from New Delhi. The village is located near the Aravallis Hills, which is a semiarid area. Even though the village is located near a highway, the transport facilities in the village are poor. Per the census of 2001, the population of the village is 3418 with 272 households. The village primarily consists of agriculture (wheat, bajra, and mustard) and dairy. The "rich" farmers have tube wells that are used to irrigate their crops. About 55% of the villagers are unemployed and a majority is illiterate and depends on daily wage earnings (i.e., laborers).

The higher caste people live in the plains where there is not a water problem, but the lower caste people live at the foothills of the Aravallis in a settlement called Harijan Basti. It is estimated that the water table is at a depth of about 200 feet at the foothills and 60 feet in the plains. There are five wells (about 50 feet deep) and none of them are functional and two ponds that are dried up. Annual rainfall between 1992 and 2002 has ranged from 392 to 661 mm with an average of 530 mm (Source: District Hydrological Office, Gurgaon).

The current water supply for the village consists of two pumps that are only operable when the electricity comes on, which is typically only for 2 to 3 hours per day and sometimes at night. Women generally spend four to five hours per day waiting in long lines to collect 10 liters of water. Even with this time and effort, there is no guarantee of water if the electricity goes off before they get a chance to fill their vessels. Other than these two sources, the villagers depend on the "rich" farmers who have tubewells. However, the untouchables must get water from outside the village in Damdana, which is 1.5 km away, because they are not allowed to get water from the common source. For them to have direct access to water, the water supply must be located in the foothills where they live.

The water problems are recognized by the people and want the Panchayat (self-governing body) to improve the situation, especially the women and young girls who have to travel long distances to get drinking water. With the decline in traditional systems that linked water with religious activities (e.g., "Johad Puja" which means worshipping of pond and "Kuan Pujan" which is the worshipping of well), there has been a marked decrease in ground water levels as people become more reliant on piped systems and tube wells. The villagers estimate that the ground water level declines six to seven feet per year. A check dam was constructed in June 2005. The villagers were involved in this project and helped to select the location and work as laborers. It is hoped that the check dam will help to raise ground water levels and that there will be a sustainable supply of water for the village.

Approval of the village's Panchayat is required before any project can proceed. The Panchayat consists of five people that are elected by the villagers and is headed by a person called the "Sarpanch." The Panchayat is responsible for the development of the entire village without

discrimination of caste, but the system of casteism still exists in villages even though, legally, discrimination based on caste has been banned.

Navjyoti, an NGO in New Dehli, has offered to help facilitate the project. Over the years, they have built a strong relationship with the Panchayat and feel that they would be quite receptive of a project to improve the water situation in the village.

Student Design to Help Alleviate Water Availability Problem
The most difficult challenge facing the University of Hartford engineering students was obtaining the information about what the "real" problems were and the necessary data to evaluate the effectiveness of their proposed solutions. The other challenge facing the team was that while there was a significant level of student interest, there was very little "work" that could be done until the problem was better defined. After considering technical issues such as fixing non-functional pumps, drilling and location of a new well, installing solar pump, storing water, providing a sustainable water supply, and ensuring potable water, the students decided to design a solar pump system for the village. However, they recognized that they were still many unanswered questions that were both technical and non-technical. These issues ranged from how the Panchayat would accept such a system if it were implemented for the lower caste and turned out to provide a more reliable source of water than the current water supply system. Also, many questions remained about funding the project, purchasing of materials, drilling of the well, installation of the pump, and training of the villagers to make it a long-term successful project. Even with students who tend to be overly optimistic, there is a general feeling that the project may not be successful or even if they will have the opportunity to visit the village.

To provide the students with some direction, the design of the solar pump was done as the project for the Solar Engineering course. The students defined the problem as:

- Pump should be low-maintenance and be powered by an abundant energy source
- Assumed that the recharge of groundwater was equal to water supplied by pump (i.e., no groundwater analysis performed)
- Well system would provide on-demand access to sufficient potable water for the village
- Storage systems should be sanitary and provide up to 5 days of storage
- Estimated water usage of 20 gallons per household per day
- Assumed piping system because location of well and village layout was not known.

The average sunlight per month for New Delhi, India ranges between six and ten hours. Using six hours of peak sunlight per day, the student design team selected a Lorentz HR-14 Fixed Tracked System. The pump has peak power requirement of 720 W and it can pump 11.5 gpm at a depth of 130 feet. Because of the decrease in efficiency over time, a system that could generate 800 to 850-watts peak solar power was selected (e.g., six Sunwize BP SX120 panels). The solar panels should be oriented to maximize the solar exposure for April when the region receives the least amount of rainfall. The solar panels should be six to eight feet above the ground in an array that is symmetrical. Each panel is approximately 30" wide, 60" high and 2" deep and weighs 30 pounds. The proposed configuration would cover about 70 square feet. The panels should be

oriented towards the solar south at 70 degrees solar altitude and the angle from the ground to the back of the panel is 9.4 degrees.

A water storage tank that was 24 feet diameter and 10 feet high (27,000 gallons) was selected. The design included a cover with several small holes to collect rainwater during the monsoon season when pumping will be significantly reduced.

Assessment of the Extracurricular Approach

A meeting consisting of three faculty from civil and mechanical engineering departments and the EWB student chapter president took place in December 2005 to discuss the advantages and disadvantages of the current approach. A summary of the advantages were:

- Students took the initiative in funding the project and their travel to India. Currently, the students have received $4000 from the University of Hartford Student Government Association and are attempting to get additional funding from corporate sponsors and the University of Hartford International Center.

- About 10 to 15 students who were most interested and enthusiastic about the project were volunteering their own time.

The disadvantages of this approach were:

- Only one of the three students who designed the solar pump was interested in participating in the project.

- No design review was done by a group of engineering professionals and/or faculty that were familiar with these types of installations.

- The changes of a implementing a successful complex project that includes integrating cultural issues and unknown on-site issues with a sustainable technical design project were reduced because the student's were depending on their "free" time from their other obligations such as school work, jobs, and other outside activities.

From this meeting, both the faculty and student decided that a more structured approach is required to make this a successful and worthwhile experience for the students.

How Can a New Course on Engineering for Developing Communities be Incorporated into the Curriculum?

Even though the idea of a new or modified course was originally rejected, it was decided to reinvestigate how we could assist those students interested in learning more about design for developing communities. The two alternatives that were the most attractive were that the design project be done as part of an existing course or a new elective course be developed. Possible existing courses that could be modified were the sophomore design course taken by all

engineering majors (biomedical, civil, computer, electrical, and mechanical) or the senior design capstone course. For the three-credit sophomore design course, an in-depth study of the design process is presented. Each section has about 20 students who work on one major project throughout the semester. The project is divided into specific tasks where teams of 3 or 4 students are responsible for completing their part of the project. A description of the course (ES 242 – Engineering by Design) is at http://uhaweb.hartford.edu/CEE/EScourses.html. For the capstone design project, each engineering program offers their own course that ranges from three to six credits. In civil engineering, a team of 3 or 4 students work on a four credit project that is mentored by practicing engineer who takes a very active role in leading the technical aspect of the project. Students provide the instructor of the course input on the area of civil engineering that interests them most so that appropriate projects can be found.

It was decided that one section of the interdisciplinary sophomore design course should have a "design for developing community" theme for the following reasons:

- By introducing this topic to sophomore students, there is the opportunity for those students most interested in sustainable development to act as mentors during their junior and senior years. It is this type of continuity from year to year and the opportunity for the villagers to see some of the same faces year after year that will improve the long-term success of the projects. Furthermore, the experience gained by one class in implementing their design can used to improve the design of the next year's class.

- The sophomore design course is already linked to an ethics course. Therefore, there is already a course in place that can help to facilitate further discussion of the ethical implications of how the project will help or may even hinder the development of a community.

- The pedagogical technique of "just in time learning" could be used in the sophomore class to teach the students the technical subjects needed for them to complete their design. It is hoped that a "tast" of fluid mechanics, hydrology, water treatment, structures, etc. would make them that much more excited about their upper level core courses.

- The project-based senior capstone design experience mentored by practicing professional engineers has been a very successful course at the University of Hartford. Many of our students stay in the area and work for the companies or local and state government entities that sponsor these projects and we did not want our students to lose that experience.

The other concern that needed to be addressed was funding for the students to implement their design. It is expected that the class will have 10 – 15 students and it is hoped that most if not all of these students would have the opportunity to travel to the village. While it is expected that students take some responsibility in raising funds, we were fortunate that Pratt & Whitney, a division of United Technologies, was interested in supporting a pilot Engineers Without Borders (EWB) project as part of their division's philanthropy program. While there are several organizations that help to facilitate these types of projects, Pratt & Whitney has selected EWB because of the assessment and implementation process that they have developed. In Pratt &

Whitney's business plan for a prototype project, they have specifically included the University of Hartford as one of the schools they would like to support. We are currently working on becoming an official EWB student chapter and then to have the Abheyur village project accepted as an official EWB project. Furthermore, the relationship with Pratt & Whitney will provide us with practicing engineers that can mentor our students in developing sustainable and appropriate technology for a developing community.

Initial Ideas on Content of Sophomore Design Course

Development of the sophomore design course is in its initial phases. One of the first tasks is to review existing courses on engineering for developing communities programs and courses. A good summary of current programs was given by Bielefeldt et al.[6] Also, EWB has a detailed assessment and implementation schedule for projects[1]. After a project has been approved by EWB, a minimum of 28 – 30 weeks are required prior before the first implementation trip. Therefore, much of the initial site assessment must occur in the fall semester prior to the spring semester design course. This will likely make it necessary to have the students pre-enroll in the class so that they can be involved in all phases of the project.

It is anticipated that there will be several follow-on projects that will be defined as we learn more about the issues facing the people who live in Abheypur. The continuity established with our students working in the same village for three or four years will hopefully provide more benefit than the sum of the individual projects. After the Abheypur projects have been completed, we do not anticipate having any difficulty in finding other projects through our contacts with Pratt & Whitney and the professional EWB-Hartford chapter.

While there are challenges in developing the technical aspect of the class, the more difficult part will be to incorporate the cultural, societal, political, and business aspects that students need to understand so that they can fully appreciate the complexity of developing a successful sustainable design that uses appropriate technologies. One good resource is an interdisciplinary course developed at Smith College by Riley and Miller that required students to critically analyze the technological, cultural, and policy aspects of international development.[7] The course included reading material highlighting various view points on globalization, history of development, success and failure of development projects, role of technology in society, and appropriate technology. It is through this type of discussion that the students become more sensitive to the group of people that they are trying to help and the benefits and limitations of what can be accomplished by visiting a village for a short period of time. Because it is likely that the engineering faculty member will not have an expertise in all these areas, the course will either be co-taught or include guest speakers that will lead the class in discussion of these and other relevant issues.

Conclusion

Although it was thought that faculty could successfully support a student extracurricular design project for a developing community, our experience has shown that a more structured classroom approach would be much more beneficial to the students. After reviewing various course options available, it was decided to modify one section of an existing interdisciplinary design course to

include a design for developing communities theme. One of the initial reasons not to use this approach was the burden on the faculty and/or department to find funding so that all students have an opportunity to visit the community and implement their design. It is hoped that through Pratt & Whitney's interest in supporting an EWB project that the funding issue will be minimized. Also, Pratt & Whitney's involvement provides a large resource of practicing engineers that can work directly with our students in designing and implementing a sustainable system.

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