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Abstract

An Engineers Without Borders (EWB) Club has operated at our University for approximately 6 years, conducting projects in Asia, Africa, Central America, and North America. EWB projects are completed cooperatively between club members and students enrolled in an experiential learning course required by the engineering curriculum. EWB projects provide real world experiences where students are called upon to use all their book knowledge, common sense and resourcefulness to make a significant contribution to project goals. Students work in multidisciplinary teams. They are responsible for interacting with clients, conducting assessment trips, designing solutions, making recommendations, producing engineering reports and drawings, making presentations, raising funds, and supervising and participating in construction. The projects introduce student to the triple bottom line, i.e., projects must work at environmental, economic, and social levels. The purpose of this paper is to describe the benefits of incorporating EWB projects into the engineering curriculum. In order to do this, three projects are described in detail, in Senegal, El Salvador, and The Gambia.

Introduction

Experiential education involves educators teaching by engaging students directly in real experiences and focused reflection. Experiential learning is a component of experiential education, i.e., learning through direct experience. Experiential education and learning can be a valuable component of engineering courses [1,2,3,4,5].

Engineers Without Borders (EWB) is a non-profit humanitarian organization dedicated to improving the quality of life for impoverished communities around the world. EWB connects students and professional engineers with communities in developing countries and provides help through the implementation of environmentally and economically sustainable engineering projects. In doing this, EWB members hope to develop internationally responsible engineering students. According to EWB literature, it is essential to develop engineers with the skills and tools appropriate to address the issues that out planet is facing today and is likely to face within the next 20 years, engineers who can contribute to the relief of the poverty afflicting developing communities worldwide [6]. The value of EWB projects to engineering students has been noted in the literature [7,8].

EWB-USA was started in 2000 by Dr. Bernard Amadei, a civil engineering professor at the University of Colorado in Boulder. In 2001, Dr. Bernard and his students designed a sustainable water delivery system for the village of San Pablo, Belize. Since then, EWB has grown to include more than 200 professional and student chapters. EWB-USA projects include water supply, wastewater treatment, sanitation, transportation, health, and shelter systems. EWB projects are initiated and completed by professional and student chapters associated with various universities and private organizations.

An EWB Club has operated at our University for approximately 6 years, conducting projects in Asia, Africa, Central America, and North America. The EWB projects are completed cooperatively between club members and students enrolled in an experiential learning course required by the engineering curriculum. EWB projects provide real world experiences where students are called upon to use all their book knowledge, common sense and resourcefulness to make a significant contribution to project goals. Students work in multidisciplinary teams. They are responsible for interacting with clients, conducting assessment trips, making recommendations, producing engineering reports, making presentations, raising funds, and supervising and participating in construction. EWB projects introduce student to the triple bottom line, i.e., projects must work at environmental, economic, and social levels.

The purpose of this paper is to describe the benefits of incorporating EWB projects into an experiential learning course in the engineering curriculum. In order to do this, three projects are described in detail, in Senegal, El Salvador, and The Gambia. The method by which projects are incorporated into our curriculum is also described.

Background

The engineering curriculum at our University has a 4 year sequence of project-based, experiential education courses called Engineering Clinic. All engineering students take an Engineering Clinic in each semester of their 4 year education. Clinics involve multidisciplinary teams of students working on hands-on problem solving. Freshman Clinic is focused on engineering measurements and competitive assessment. Sophomore Clinic is focused on engineering design. The sophomore year also has significant communication components, both writing and speaking, and is team-taught with communications faculty.

In Junior and Senior Clinics, students work in small teams of juniors and seniors on open-ended projects under the supervision of one or more professor. Each team works on a unique project, which can be multiple semesters in length. A typical sequence includes: information search and review; development of a clear and concise problem statement; research and/or design and testing activities; and presentation of results via written report and presentation. Projects have ranged from modeling bridges to demonstration of new site remediation technologies. Most projects are funded by industry or governmental agencies. Over 60 projects are run in a typical semester.

The clinic portion of EWB projects, so far, has been conducted as part of Junior and Senior Clinics. Non-engineering and Sophomore engineering students have participated through Independent Study courses. Additional students have volunteered their time through the EWB student club. EWB projects involve experiential learning because students carry out real projects. Students commit to communities in need through EWB. They travel to the communities to gather data and make conections. Once sufficient data is gathered, the students identify alternative solutions and present them in an engineering report. They then work with the community to select, design, and implement the best solution. Often, significant fund raising is carried out by the students.

Inherent to all EWB projects are service learning aspects. Service learning can be defined as "a form of experiential education in which students engage in activities that address human and community needs together [9]." Through service learning students obtain hands-on experiences that initiate learning and development, promoting self esteem, social responsibility, communication skills, global issues, and other skills [10].

Service learning provides an opportunity for students to engage in social and civic duty through the application of their engineering knowledge [11]. Service learning provides valuable lessons to students on how the implementation of engineering projects that address basic human needs such water, food, health, and sanitation leads to the improvement of the quality of people lives. While learning about the culture of a host community, students have an opportunity to understand the value of their own culture from a different perspective.

Service learning through EWB also exposes students to the culture, language and daily life of host communities through data gathering activities, project implementation in the host community, and simply spending time with local people. They also see how engineering projects can improve the quality of life in the host community. EWB projects expose students to cultures of which many students are completely ignorant. Students gain a better understanding of technology and the interaction between technical and non-technical issues. Students work on real world projects, with real constraints and unexpected problems. Through EWB projects, students can better understand the impact of technology while enhancing their communication and leadership skills [12].

EWB projects provide a platform to integrate social, economic, and environmental considerations into engineering design in a significant way [11]. The goal of EWB is to create sustainable engineering projects in impoverished areas worldwide including United States. EWB projects provide students with an opportunity to apply their engineering skills to solve the community problems. Through EWB projects, students develop skills not often taught in class, such proposal writing, project management, professionalism, interacting with clients, team work, fund raising and leadership skills.

Three EWB Clinic Projects

Senegal

In March of 2007, a team of 4 students, a faculty member, and an unaffiliated medical doctor traveled to Ngonine, Senegal, to evaluate the potential of extending a nearby water supply line to the village. The medical doctor, the father of one of the traveling Rowan students, had previously visited the area to offer medical services through his professional clinic. He had determined that the local population of Ngonine was suffering from a variety of afflictions, including malnutrition, typhoid, dysentery, lethargy, and poor eyesight. A lack of clean drinking water contributed to these problems.

As the Rowan team arrived, they learned that Ngonine had two main sources of water – local, shallow wells, and a government-regulated deep groundwater well and pump system. Most of the community members had a shallow well just outside their homes. However, the Rowan students performed some simple water quality experiments and determined that the water had high levels of salinity and fecal coliform. The deep well was located about 3 kilometers away from the village center, and a fee was charged of about 3 cents per cubic meter of water to deliver water. The students also tested this well's water and found no harmful levels of bacteria present. At this well there was a ten-meter tall water storage tower and a ground-level outlet. By use of a questionnaire, the students determined that the distance was the main deterrent for the community to access the clean water. The water is mainly collected by the women of the community, and they indicated that they could spend up to five hours each day on this chore.

After returning from the trip, the students designed a water distribution system, including pipes from the existing well, public faucets within Ngonine, and a payment method for water users at each tap. The students had to determine how feasible this plan was. To determine whether the ten-meter tall storage tower provided sufficient potential energy to provide sufficient water through up to seven kilometers of pipes, the clinic students modeled the system in a readily-available program, EPANET. To learn more about this program, developed by the Environmental Protection Agency, visit http://www.epa.gov/nrmrl/wswrd/dw/epanet.html. The students were tasked to learn this program on their own. After several simulations, a feasible pipe layout and design was identified. The design of this pipe system was delivered to a local Senegalese contractor who supervised the final construction and implementation. Students learned a great deal from this project, e.g., they learned the importance of obtaining new skills, such as the operation of EPANET, to solve problems. Figure 1 shows two engineering students exploring life in Ngonine.

Figure 1: Engineering student pounds millet

El Salvador

In May of 2007, Rowan EWB sent a team of students and faculty to La Ceiba, El Salvador to assess a water supply problem and collect data necessary to develop a sustainable solution. The travel team included students from the clinic and the club. The citizens of La Ceiba were surveyed to evaluate the impact of water quality, quantity and access. It was determined that over 30 children had died in the previous 5 years due to water-borne illness. The local hand-dug wells and nearby river, the primary drinking water sources, were examined and found to be contaminated with fecal coliform. In preparation for a possible water distribution system, over 200 land survey points were collected.

After the initial assessment trip, a problem definition was developed. Design constraints were identified and criteria for choosing a best solution established. Rowan EWB members conducted a comprehensive literature search to identify alternative solutions for the community in La Ceiba. Alternatives considered included solar disinfection, household biosand filters, renovating existing household wells, and the installation of a new town well with distribution to taps distributed through the community. Two solutions were selected for further evaluation: household filters and a town well and distribution system.

In March 2008, students returned to La Ceiba. The primary focus of this trip was to meet with the community to select a solution and plan its implementation. The community strongly favored the new town well and distribution system. They created a water committee and committed to obtaining necessary permits, obtaining legal access to a property suitable for a town well, and developing a system to collect fees to maintain the system once constructed. They also committed to digging the trenches necessary for the distribution pipes. Students also went house to house during this trip educating community members about currently available water treatment options, e.g., solar disinfection and the use of a locally available chorine-based disinfectant called Puriagua.

Since then the students have designed the well and distribution infrastructure, using AutoCAD and EPANET, but the project has temporarily stalled, as the community is still working on land access and permits. Once this hurdle is overcome, a well will be drilled, the pump and related infrastructure installed, trenches dug, and the distribution system installed. Students will travel back to the community to supervise and participate in various phases of the construction. Students learned a great deal from this project, e.g., the importance of public meetings to engineering projects. Figure 2 shows engineering students leading a town meeting.

Figure 2: Town meeting in La Ceiba

The Gambia

Students travelled to Sambel Kunda and 7 other nearby villages in January 2009. Clinic students had spent the Fall 08 semester preparing for the trip. The travel team included two students from the clinic and one student from the club. A 4 km section of a local road floods for approximately 6 months each year. During the height of the rainy season, sections of the road are as much as 3 or 4 feet under water. The surface of much of the section becomes very muddy, impeding travel by foot, donkey cart, and motorized vehicle. Even during the recent assessment trip, more than 3 months after the rains stopped, small sections of the road were still muddy or even submerged. Between July and January, no motorized vehicles, other than tractors, were able to navigate the road. Women and children must travel the road, on foot or by donkey cart, every day to tend rice fields and go to school in Kuntaur, respectively. Everyone in the 8 villages travels the road to go to market.

During the recent assessment trip, students conducted a health survey of the residents of the 8 villages, met with local leaders, and surveyed the road. Information on the history of the road was obtained, as well as the availability of local materials and equipment. Finally, the willingness of the local community to participate in repair work and keep the road maintained was assessed. Students were exposed to a culture very different from the United States. The villagers live without electricity and subsist largely by tending crops and animals by hand. The local religion is Muslim with vestiges of earlier religions.

Student also met with representatives of the Gambian National Road Authority (GNRA) to ensure cooperation and obtain additional information about local design methods, materials, and equipment. They will present their design report to the GNRA to ensure cooperation and coordination. Students learned a great deal from this project, e.g., they learned that design specifications vary throughout the world. Roads in Gambia are typically built using Laterite gravel quarried locally. Hard gravels, geotextiles, and other materials commonly used in the USA are unavailable.

The Spring 2009 semester is committed to developing alternative solutions, selection of a small number of solutions for a more detailed design. It is likely that the design solutions will range from repairing the entire 4 km using manual labor to repairing the entire 4 km using machines such as bulldozers, compactors, and graders. Students will evaluate solutions using cost and other criteria. They will also continuing to raise money for the project. Figure 3 shows an engineering student and villagers using the total station.

Figure 3: EWB student and villagers use total station

In the interest of fostering reflections, the students have been asked to write about what they took away from the trip. For example, what did they learn about Gambia? Themselves? The developing world? The USA? Engineering? The results of this reflection will be available for the presentation at the annual meeting.

Discussion

The three projects presented are at three different stages: completed, in the implementation stage, and in the design stage. EWB clinic projects incorporate experiential learning into the engineering curriculum. EWB clinics allow students to experience real engineering in a global context. While taking clinic and other engineering classes, students must learn to balance their time wisely. A student that is a part of a EWB clinic makes real contributions in terms of trip planning, data gathering, brainstorming, detailed design and drawing, assessment, report writing, client communication, etc. EWB at Rowan teaches young engineers early in their academic pursuits to be conscious of sustainability and environmental concerns. Being a part of Engineers Without Borders and travelling worldwide gives students experiences they could not attain in a classroom. Service learning gives students the opportunity to make a difference by solving real life problems around the world, affecting hundreds of people in developing and impoverished countries. In doing this, EWB members are given a new global perspective as well as taught skills that will make them better engineers in workforce, and citizens of the world.

By having some students participate in EWB through an official class, the clinic, professors are able to maximize the student experience. For example, students write real engineering reports, which are revised until acceptable, and the best solution is selected after rigorous comparison, not because it was the first feasible solution identified. EWB clubs do great work, but an EWB clinic better develops students' engineering skills. Professors are also able to require that student record their reflections in a written document; thus, encouraging better reflection.

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