

Engineers Without Borders – USA, Learning Through Humanitarian Service to Underdeveloped Communities

Willard Nott¹, Adam Christensen², Douglas Edwards³, Peter Bosscher⁴, Cathy Leslie⁵, Samuel Graham⁶

Abstract - This paper describes the Engineers Without Borders-USA program to educate and train internationally responsible engineers and engineering students. EWB-USA partners with underdeveloped and developing communities to improve their quality of life by implementing sustainable engineering projects using appropriate technology. EWB-USA continues to expand its role in the education community at the university level and has started programs at the pre-college levels. These efforts stress humanitarian, service learning through the application of real world projects, and allow students to confront cultural as well as technological issues. Students have the opportunity to gain a different perspective of their own culture and values through the lens of other cultures, and experience the positive and negative interaction between technological and social change.

Key Words- Appropriate technology, Engineering Education, Humanitarian, Service Learning, Sustainability

INTRODUCTION

Engineers Without Borders – USA (EWB-USA) (www.ewb-usa.org) is a non-profit 501(c)(3) tax-exempt US corporation based in Longmont, Colorado, USA. It is a humanitarian organization consisting of a partnership of professional and student engineers, whose purpose is to utilize sustainable, appropriate technologies to improve the quality of life of developing communities. EWB-USA seeks to achieve that goal by training internationally responsible engineers and engineering students while benefiting the host communities [1].

EWB-USA stresses the design of sustainable systems that developing communities can own and operate without external assistance, and seeks to empower communities by enhancing local, technical, managerial, and entrepreneurial skills. Projects are initiated by, and completed with, contributions from the host community working with EWB-USA project teams and other cooperating organizations. While there are professional and student chapters, this paper will concentrate on university and pre-college programs. The program is relatively new and research has not been

performed on its effectiveness. This paper will be primarily descriptive with anecdotal observations.

HISTORY

EWB-USA was started as a result of the concerns and actions Dr. Bernardo Amadei from the University of Colorado in Boulder. In 2001, Dr. Amadei and a team of his students designed and built a water delivery system in the village of San Pablo, Belize at the request of the Belize Ministry of Agriculture. Most adults worked at a nearby banana plantation, the responsibility for carrying drinking and irrigation water, from the nearby Swasey River, to the village, fell to the young children, preventing them from attending school, and thereby maintaining a cycle of poverty in the community. That project resulted in the first EWB-USA chapter and incorporated as non-profit organization in June 2002 [2].

Since then, the organization has grown to over 230 chapters ($\approx 73\%$ University and $\approx 27\%$ professional chapters and one High School Chapter) with over 7000 volunteers at the time of this writing. It is currently growing at the rate of 50% per year. There are projects completed, in process, or open for assignment in over 40 countries. Projects include water supply and treatment, energy, health and safety, education, agriculture, building and bridge construction, micro-enterprise, and sanitation.

STRUCTURE

The headquarters for EWB-USA is located in Longmont, Colorado, USA and managed by six full and part-time employees. All other people associated with the organization are volunteers. The chapters are created by interested engineers, students and/or faculty applying to EWB-USA.

Projects are proposed by the community to the national office or to a specific chapter. All proposals must be approved before a chapter is allowed to proceed. All proposed designs must be approved by the Technical Advisory Committee (TAC) before implementation to insure sustainability, appropriateness, feasibility and quality.

¹ Willard Nott, Engineers Without Borders-USA/EAST Initiative, nottw@asme.org

² Adam Christensen, Georgia Institute of Technology, adam.christensen@gatech.edu

³ Douglas Edwards, Westlake High School, edwardsd3@fultonschools.org

⁴ Peter Bosscher, University of Wisconsin, bosscher@engr.wisc.edu

⁵ Cathy Leslie, Engineers Without Borders-USA, cathy.leslie@ewb-usa.org

⁶ Samuel Graham, Georgia Institute of Technology, sgraham@me.gatech.edu

Chapters are asked to establish an extended relationship (5 years minimum) with a community to better understand their needs and the impact of their efforts, and to improve the sustainability of partnership. A chapter will often implement several projects in phases.

A regional structure based on geographical location of the chapters has been started to help relieve the management burden on the paid staff. Regional conferences are held to provide workshops, training and networking.

A pre-college program has been started with one high school chapter officially chartered.

UNIVERSITY PROGRAMS

Engineers Without Borders – USA has proven to be a very popular and fast growing program in the university setting. Students are seeking opportunities to become involved in real world projects that have beneficial, humanitarian outcomes. The potential benefits from service learning include:

“Increased student recruitment, retention and involvement, especially among women and underrepresented minorities;

-Increased student’s understanding of technology and the interaction between technical and non-technical issues;

-Opportunities for students to work in a real world environment, with real constraints and unexpected challenges;

-Having a legitimate opportunity to fail, ... step back, evaluate ..., and try again” [3].

Since most EWB-USA university chapters are fairly new, they are generally extracurricular rather than being integrated into the regular curriculum. The most common efforts to incorporate EWB activities into engineering courses have been to use them as the senior design projects required of most engineering students. Examples of three different programs are described.

University of Colorado, Boulder
(ceae.colorado.edu/ewb/)

As the first chapter and home of the founder, the University of Colorado, Boulder has a well-developed program. In addition to the first project in Belize, the chapter also has projects in Muramba & Mugonero, Rwanda and San León, Peru. The projects include solar lighting, cooking, education, water supply and water treatment. In the Rwanda project, the chapter is partnering with EWB-USA chapters at the University of Wisconsin and Johnson Space Center. The field experience provided by the projects complements the academic engineering programs as denoted in Figure 1.

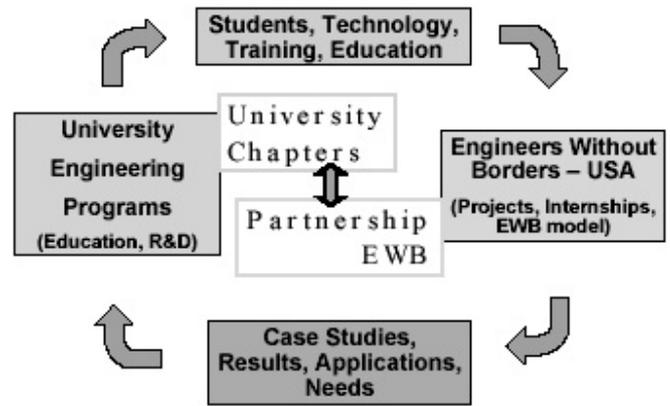


Figure 1: EWB-USA and University Relationship [1].

A track entitled “Engineering for Developing Communities” (EDC) has been added to the traditional Civil and Environmental Engineering B.S. degrees. The track is interdisciplinary involving non-engineering disciplines and non-academic groups along with traditional academic engineering programs [1]. The students learn practical applications of sustainable, appropriate technology. They are also learning “the importance of intentional listening” [4]. Defining the problems and implementing the solutions requires developing strong communication skills with those of another culture and language that transcend the technological issues. The EDC program “was initially driven by the large student interest” [4]. Evaluation of the program is still under assessment.

Tufts University
(ase.tufts.edu/ewb)

The Tufts chapter is associated with three projects. The current ones include a model green building in Ecuador and a water filtration system in El Salvador. The chapter also brought together different schools and departments to work on water quality, health and construction projects for a small community in Tibet. The community is transitioning from a semi-nomadic group to a stationary community facing “new problems of depletion of natural resources and sanitation” [5]. The chapter brought in students from the School of Arts and Sciences in addition to different departments of the School of Engineering. The partnership included British doctors from the KunDe Foundation. The Mechanical and Civil Engineering faculty acted as design consultants and integrated the project into the “senior capstone design coursework, senior thesis credit, and undergraduate special topics courses”. [5] Elective credit for research was also available to students from the School of Arts & Sciences. Students comments included:

“-Using the principles and theories I learned in my physics classes to build a functioning tool was something I don’t think I had ever done before.”

“-I learned about group dynamics on an international scale, and learned that helping also means being helped, strengthened my views on our responsibilities as international citizens with the available means, and

witnessed the incredible strength, cohesion and possibilities achievable through community.”

“... engineering can be applied toward the bettering of communities both on the local and global level. Classes suddenly had more meaning through their newly discovered relevancy to what I wanted to be doing with my life. I also discovered my ability to be a leader and inspire others into becoming engaged” [5].

Benefits of this program include understanding of the impact of technology, enhancing communication and leadership skills, ability to think outside the technical box, and realizing professional and social responsibilities go together [5].

University of California, Santa Barbara
(www.engr.ucsb.edu/~ewb-ucsb)

This chapter is associated with completely different projects in Peru, Thailand and Mali. The Araypallpa, Peru project involves three distinct subprojects; a solar panel for the school, a water purification system, and a full assessment of the sanitation system. The team includes students from electrical, mechanical, industrial, and chemical engineering, as well as from materials science, environmental science, geography, physics, biotechnology, film studies and social anthropology. [6] The film studies class made a documentary of the various stages of the project including many of the difficulties faced. It was a well-received educational tool that was shown at the West Coast Regional and International EWB-USA conferences. The students reported that communication within the team and with the community members and other local resources was a highlight in their learning experience. Social and economic issues were examined in addition to the technological/design considerations. Lessons learned that were reported by the students included how to work under tight constraints, how to coordinate tasks between diverse groups, and the need for flexibility in design. Community ownership and understanding the daily life of the community were significant issues for project sustainability. The Thailand project involved construction of a school dormitory and a sanitation system. Since the government was imposing the educational system, it was an effort to develop an appreciation for an education geared toward interaction with the outside world. The Mali Folk Center is looking for means to extract the oil from *Jatropha* nut for biodiesel fuel. The nut, while plentiful, is not edible. The chapter is developing a workable design to provide a useful energy source for the community. All of these projects have produced a wide variety of challenges for the students.

PRE-COLLEGE PROGRAMS

EWB-USA recently decided to develop programs suited to the pre-college level (elementary, middle school and high school levels in the United States) for three reasons. First, it provides a unique opportunity to intimately link engineering, ethics, and social studies, which can increase the awareness of the beneficial aspects of engineering. By involving students with these interdisciplinary projects early in their

educational career, a stronger sense of “learning purpose” might be instilled. This could potentially lead to further self-exploration, genuine inquiry, and the development of the next generation of engineers/scientists/humanitarians. Secondly, this project initiative will help provide a flow of new volunteers to the organization early in their studies. Since the current structure of EWB is one heavily based on volunteerism, new talent is always in need. Thirdly, developing a pre-college program will provide more opportunities for university students to become engaged in local projects (i.e. tutoring younger students, local clean-ups, and smaller scale engineering projects).

The pre-college activities will stress the multi-disciplinary aspects of the projects including technology, design, and cultural, political and economic issues. EWB-USA is partnering with Junior Engineering Technical Society (JETS), American Society of Mechanical Engineers – International (ASME), American Society of Civil Engineers (ASCE), and CH2M HILL (a global full-service engineering, construction, and operations firm) to implement the programs. JETS has an established engineering program and clubs at the pre-college level, which serves up to 40,000 students each year across the United States. Fifty-three percent of all JETS students are from groups traditionally underrepresented in engineering and technology and 36 percent of total participants are female.

At present, three levels of pre-college programs are planned (subject to revision). The first level will develop lesson plans based on the EWB-USA Project of the month. They will be structured to allow scaling for different educational levels and subjects. The plans will be easily downloaded for free by anyone for use in their particular educational setting. The second level will specify an actual project in a developing community that schools can address over a period of 3 to 6 months. School teams will research the problems and work on solutions to the design problems, which will be reviewed by EWB-USA, JETS and members of the community submitting the engineering problems. Any, or a combination of, the solutions may be further developed at the discretion of EWB-USA and the host community. The first community to host this program will be the United African Alliance Community Center (UAACC) (www.uaacc.habari.co.tz) in Arusha, Tanzania that is currently working with the Westlake High School Chapter. Third, schools will be allowed to form an official EWB-USA chapter under the sponsorship of a university or professional chapter. One high school, Westlake High School, part of the Fulton County School System in metro Atlanta, Georgia, has achieved that status.

EWB-Westlake High School Chapter

The Westlake High School (WHS) Chapter represents the initial motion to push EWB concepts and methodologies into a pre-college environment as an official chapter of EWB-USA. The efforts at Westlake High School have been multifaceted in order to establish a platform that can be easily adopted for future development of the chapter. Development has been focused primarily on an after school club, class curriculum development, and summer research

experience at Georgia Institute of Technology. These facets allow for a total learning environment where the elements of engineering and humanities can be combined in ways that provide a sense of learning purpose. In addition to these learning environments it was also found that there was a significant amount of overlap between the Junior National Society of Black Engineers (NSBE Jr.) and the EWB club. Therefore efforts were taken to open communication between the two clubs in order to diversify our group. As another extension of the EWB club, and as direct result of the multifaceted efforts occurring at Westlake High School, there are possibilities to participate in EWB themed summer research through the efforts of the Center for Education Integrating Science, Mathematics, and Computing (CEISMC-www.ceismc.gatech.edu). In these settings it will be possible to highlight individual engineering interests of the students.

Westlake High School (WHS) is a diverse and prominent institution within Fulton County, Georgia. Accredited by the Georgia Department of Education and the Southern Association of Colleges and School, WHS houses a science and technology Magnet program that offers high performing classes for students with those interests. The structure behind the EWB-WHS chapter was set up as follows. A class in "Topics in Engineering" is offered and highlights the history, ethics, and project management behind any engineering project. The first semester of this class is in a more traditional setting. The second semester is project based, and is graded on a learning contract system. This system allows for students to commit to a grade of their choice but requires projects be executed in an exemplary fashion. It is through this learning contract that some of the EWB projects have been brought into the class curriculum. In addition to the engineering project management issues, there are also significant social engineering management issues with any project in a developing community. For help with social issues that are faced in a typical northern Tanzanian village the "Topics in Engineering" class collaborated with an "African Studies" class. This opened up another path for communication between the humanities students and the engineering students.

In addition to the classroom curriculum development, an after school club was established. The club met three times per week, twice in the mornings where organizational issues were primarily discussed and then once in the afternoon where the focus was on construction of prototypes and further design analysis. The club was organized with a team of coordinators rather than tradition "presidential" roles. The WHS club consisted of a Project Coordinator, External Affairs Coordinator, Financial Coordinator, and Internal Coordinator; each coordinator had responsibilities towards the managing the project, contacting interested outside parties, finances, and distributing important information internal to the club, respectively. The students in the club were initially working on a project (a solar powered thermoelectric refrigerator) that had no specific ties to a community in the developing world. Instead this project was used in order to introduce some more advanced physics concepts and tie them into a humanitarian and

environmentally friendly theme. By the second semester the WHS club had formed a partnership with the United African Alliance Community Center (UAACC) in Arusha, Tanzania in order to develop a solar cooker. The idea for a solar cooker was brought to the club's attention by the Tanzanian village. They had a need for a non-polluting, inexpensive, and reliable replacement cooking system. By developing this connection between the UAACC and WHS the club will be participating in an actual implementation of their solar cooker design in Tanzania. One of the main benefits of this program is the ability to show the students a project from beginning to end. However, the ability to participate in a project that will impact the lives of others greatly enhances the impact that it has on the students.

WHS Program Evaluation

While a formal evaluation of the EWB club has not yet been implemented, some anecdotal evidence has been collected on the students' impression of the program. When asked "What did you like about the EWB club?" one student replied with "*I liked the networks I built and [what] I liked the most [was] the possible effect on communities that can use what we build.*" Another student commented, "*I like the fact that we actually do stuff; we don't just talk about how we're going to help people - we do it.*" Other students answered with similar responses, which indicate that a connection to a real-world project might be a critical component for developing a strong sense of project purpose. The students were also asked "Did you feel like the EWB club reinforced previous knowledge, provided new knowledge, or didn't teach you anything new." Again, many of the students responded with similar statements. A representative response was made by one student; "*I not only feel that EWB sucked forgotten knowledge out of me and made it worth using, but it also taught me knowledge I could use in class as well as corporate America.*" Since the WHS chapter was a new club format it was important to evaluate how to make future improvements. The students were asked, "What do you think we could do better next year?" One student responded with "*We could raise more money, stay focused, and do better research for our projects.*" Another student stated; "*Next year, I think we should let the students choose the project.*" Yet another student commented; "*Next year we could get an active online agenda and event keeper.*"

All the comments made by the students indicate that the program was successful in bringing engineering and humanities together into one interdisciplinary project. The recommended improvements for future years will be taken seriously and can be used by others in order to refine their own projects.

Two other schools are actively seeking to establish chapters. Robinson Secondary School in Fairfax, Virginia is planning to work with a school in Roatan, Honduras. Eureka Springs High School in Eureka Springs, Arkansas works on a number of service learning projects under the auspices of the EAST Initiative (www.eastinitiative.org). The school wants to expand the scope of their projects with EWB-USA. Many other requests for information regarding the pre-college

program have received from teachers, parents and students. All of these pre-college programs and interest in them has been generated without any external promotion. That suggests there is a strong desire to bring EWB-USA to the pre-college arena.

CONCLUSION

Engineers Without Borders – USA is providing, students with extensive service learning opportunities that brings together practical, real world experience, multidisciplinary problems and multi-cultural issues. The program is rapidly expanding and developing. It is too early to draw conclusions without further study, but the anecdotal evidence is very encouraging.

ACKNOWLEDGMENT

The authors acknowledge the assistance and sponsorship of CH2M HILL, ASME, International, ASCE, Rotary International and JETS to the Engineers Without Borders educational program. In addition Mr. Christensen would like to extend his appreciation to the Georgia Institute of Technology's Student and Teacher Enhancement Partnership (STEP) program, through which he obtained a fellowship to work with Westlake High School.

REFERENCES

- [1] Bielefeldt, Angela R., et al, "Creating an Engineering for Developing Communities (EDC) Emphasis in Environmental Engineering", *Proceedings of the 2005 ASEE Annual Conference & Exposition*, Session 2451, 12-15 June 2005, 15 pp
- [2] Engineers Without Borders–USA, "Our History", www.ewb-usa.org/history.php, 2007, 1 pp
- [3] Sandekian, Robyn, et al, "A summary of the Workshop on Integrating Appropriate-Sustainable Technology and Service-Learning in Engineering Education", *Proceedings of the 2005 ASEE Annual Conference & Exposition*, , 12-15 June 2005, 8pp
- [4] Eman, Thomas., et.al, "Engineering Education Through Service Learning: Two Case Studies", *2006 ASEE Annual Conference & Exposition*, 18-21 June 2006, 8 pp
- [5] Freeman Sarah, et al, "*International Citizenship and Global Service Leadership–The Role of Interdisciplinary Teams in Engineering Education*", *Proceedings of the 2006 ASEE Annual Conference & Exposition*, 18-21 June 2006, 10 pp
- [6] Blass, Doctori Blass and Dinh, Mary Hong Loan, "*Interdisciplinary approach to a multi-phase engineering Project for the Developing Community of Araypallpa, Peru*", *Proceedings of the 2006 ASEE Annual Conference & Exposition*, 18-21 June 2006, 10 pp