# 2006-1111: RICE UNIVERSITY ENGINEERS WITHOUT BORDERS: AN EXERCISE IN INTERNATIONAL SERVICE LEARNING

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# An Exercise in International Service Learning

## Introduction

The Rice University chapter of Engineers Without Borders (Rice-EWB) is revolutionizing the education of engineering students at Rice University through the completion of international engineering service projects in the developing world. Through hands-on problem-based learning, Rice-EWB facilitates and promotes the development of practical engineering expertise, project design and international project management experience, strong leadership skills, and perhaps most importantly, the development of socially, economically, and environmentally conscious engineers. Engineers Without Borders - USA states that it is essential to "develop engineers who have the skills and tools appropriate to address the issues that our planet is facing today and is likely to face within the next 20 years, who are aware of the needs of the developing world, and who can contribute to the relief of the endemic problems of poverty afflicting developing communities worldwide"[1]. It is the goal of Rice-EWB to make positive change in the developing world while simultaneously developing engineers who are capable of tackling the challenges that confront our world.

## Overview of Rice-EWB

Rice-EWB is an entirely student run nonprofit organization dedicated to helping communities in the developing world improve their quality of life through the implementation of engineering projects that address basic needs for water, sanitation, shelter, bridge, and energy systems. By bridging the gap between those looking for help and those eager to help, Rice-EWB facilitates the completion of service projects that profoundly affect a community and promote the development of socially and environmentally conscious engineers with outstanding leadership skills and practical, hands-on, international engineering experience. Rice-EWB projects stress community partnership, reliable and sustainable technology, and the importance of education, training, and empowerment in creating a lasting, positive effect. All Rice-EWB projects are supported entirely by donations from family, friends, charitable organizations, and corporations.

Since its establishment in April of 2003 by students Abigail Watrous, Michael Higuera, and Tamar Losleben, Rice-EWB has grown into the university's largest student run engineering organization on campus. As the inaugural project, the three founding members joined the University of Colorado chapter of Engineers Without Borders to implement a rainwater catchment and water management system in the remote village of Foutaka Zambougou, Mali. Once back on campus, the founding members began work to initiate three international engineering service projects, one in El Salvador, one in Nicaragua, and one in Mexico. The chapter has since added a fourth project, also located in Nicaragua. Since its founding, the organization has grown steadily and now has over sixty five active student members, several professional mentors and advisors, and a yearly operating budget of over $40,000. Rice-EWB has become one of the most prominent and active Engineers Without Borders chapters in the country and was awarded the 'Sustainable Legacy Award' at the 2004 EWB-USA National Conference and the 'Appropriate Technology Award' at the 2006 EWB-USA International Conference, which was hosted by Rice-EWB at Rice University from February 16th through 18th.

Rice-EWB is unique because it is managed and maintained entirely by students at Rice University. A governing board of thirteen students oversees the activities of the entire organization and student project leaders manage each project team. Students manage everything from chapter organization to fundraising to training to design to implementation. Rice-EWB gives students the opportunity to control and enhance their own education.

Rice-EWB is associated with the Civil and Environmental Engineering (CEE) Department at Rice University and works with professors and professional engineers in the Houston area and in our project-countries. Professional mentors serve as advisors and help to make sure students run their project teams at a professional quality. Faculty and professional advisors serve as technical resources as needed.

Unlike classroom assignments, Rice-EWB's projects affect real people, cost thousands of dollars, and take place in a foreign country. These challenges force students to approach these projects much differently than they would a school project. First, as most projects take between two and three years to complete, student leaders must create a vision for their project with a clear picture of where they want their project to be in a year or two and how they will accomplish their goals. Second, as project teams range from 10 to 20 members, project leaders must learn to be effective leaders and to maximize the potential of the team. Third, students must master the engineering disciplines as well as the sustainable and appropriate technologies that will be used in their projects in order to teach other student members and to train community members to help construct and maintain the project. Fourth, Rice-EWB projects require leaders to be excellent project managers who can create and meet budgets, timelines, and quality control standards while keeping their team members on task and moving forward. Finally, students must learn to solve the problems that are created while working with people of a different country due to distance and language barriers. Furthermore, students must learn to be sensitive to the cultural differences present in the project communities.

Many engineering programs across the country are trying to incorporate these skills into their curriculum, and many engineering firms are searching for graduates with these skills. It is, however, supremely difficult to teach such skills in a typical engineering class. Rice-EWB, and the real-world international project management experience it provides, is playing an invaluable role in helping to educate and prepare Rice's engineers for the challenges they will face and the roles they will fill in today's global economy.

**The Rice-EWB Experience**

Rice-EWB project teams, each with between 10 and 20 student members, work year-round on their projects, and travel to their respective countries during winter break, spring break, and summer break as needed. The Rice-EWB process can be broken down into three distinct phases, each centered around a trip to the project country. The first phase of a Rice-EWB project is the exploratory trip. Using in-country contacts, the project team identifies several towns with problems that Rice-EWB might be able to help solve. The team sets up meetings with the communities of interest, and then a team of 3 to 5 students travels to the country to interview

each community and assess the problem to decide whether or not the project is appropriate for Rice-EWB. The team then chooses a project that it will work on for the next two to three years.

After completing an Engineers Without Borders – USA project application, the next phase is the survey trip, where a team of five to seven students travels to their community to gather all the information needed to design the project at Rice University. Before the trip, students must create a preliminary project design in order to determine what information will be needed to complete a final design. Students then train themselves in all of the skills needed to gather information pertaining to the project. While in the country, students perform topographical surveys, water testing, health surveys, and look into material availability. The team also works to establish the leadership and infrastructure inside the community that is needed to ensure the long-term sustainability of the project.

Upon returning to campus, the team begins work on the implementation phase of the project. Students, with advice from professors and mentors, research appropriate solutions and develop a project design and an implementation plan. The students, throughout this process, work with the community in designing the project to ensure that the solution is appropriate for the community and accepted by all. Before the implementation trip, students are trained in the necessary construction and implementation skills. Once the team is ready, a team of seven to ten students returns to the country to work with the community to construct and complete the project. Even after the project has been completed, Rice-EWB regularly returns to the community to maintain ties and to work on improvements and other projects in the area.

In addition to project team activities, Rice-EWB holds periodic training sessions for all members to teach skills that will be needed to complete projects in the field. Past training sessions have focused on photovoltaic power systems, surveying techniques, preparation and use of concrete, masonry, cistern construction, and methods of water testing. Rice-EWB has also worked with outside experts to hold welding, solar power, and soil analysis training sessions. Furthermore, Rice-EWB has worked with the CEE department to develop a series of academic courses, related to the problems Rice-EWB teams face while working on their projects.

In just three short years, Rice-EWB has grown into a very influential and respected organization. Students have joined Rice-EWB in record numbers because it offers a chance to travel internationally and an opportunity to put engineering skills to use in a real world setting for a worthy cause. Rice University, and especially the CEE department, has rallied to support Rice-EWB because, through its projects, Rice-EWB promotes the development of leadership and project management skills, project design experience, and a sustainable and environmentally conscious approach to engineering. The Houston engineering community has also reached out to financially support the efforts of Rice-EWB because it sees value in helping to create engineers with international engineering experience who will be better able to operate in a global environment. Rice-EWB has shown that student-led experiential education and service learning have a place in today's universities, and that programs such as Rice-EWB are invaluable to the education of tomorrow's engineers.

**University and Community Support**

Since its inception, Rice-EWB's role inside Rice University and in the Houston community has grown immensely. As Rice-EWB has expanded, the university and the Houston community have rallied to support its growth and to assist in the education of Rice-EWB's members. The institutional support of the CEE department and the financial support of Houston area engineering firms and community organizations have been essential to the success of Rice-EWB.

Rice University, and especially the CEE department, has been an incredible resource for Rice-EWB. Rice-EWB is associated with the CEE department, and has worked closely with the department in its endeavors. Rice-EWB has become a major part of the department's long-term commitment to create an innovative, hands-on, design based, team oriented curriculum that prepares students for the challenges of the next century. The department has worked to provide the infrastructure needed to operate Rice-EWB and to integrate Rice-EWB into its curriculum so that the opportunities made available through Rice-EWB can be augmented by the department's resources and faculty. The CEE department has supported the work of Rice-EWB in many ways. First, the CEE department has been the custodian and guardian of all of Rice-EWB's funds, and it has transferred its non-profit status to Rice-EWB to aid in the fundraising process. Second, the department has generously provided a large office in which Rice-EWB can hold meetings, store equipment, construct experimental test systems, and run training sessions. Third, the department, in an effort to train Rice-EWB members in the latest technologies, has purchased state of the art water testing and surveying equipment for use by Rice-EWB. Fourth, the CEE department has worked with Rice-EWB to create a series of academic courses designed specifically for Rice-EWB students. These courses do not replace the experiences gained working on Rice-EWB projects, but they greatly enhance the educational opportunities present for engineering students and aide in the completion of Rice-EWB projects.

One of the most difficult aspects in service learning and experiential education is finding a way to convert or translate projects and experiences, which are inherently located outside the classroom, into a traditional academic setting. To this end, the three classes that the CEE department and Rice-EWB have worked to create have been essential in bridging traditional education and experiential education while also offering a means for students to receive academic credit for work done for Rice-EWB. The first class created for Rice-EWB members was a project management course dedicated to teaching the leadership and management skills needed to run a large service organization as well as an international engineering project.

The second class created for Rice-EWB, CEVE 315: Sustainable Technologies, has become a permanent course open to all students and all majors. This class focuses on exposing students to applicable, sustainable, and environmentally friendly technologies that can be used to better the quality of life in the developing world. Students enrolled in this class explore sustainable methods of water purification, energy production, lighting, waste management, and cooking. Students working on Rice-EWB projects often focus their class work on issues their Rice-EWB teams are facing with their international projects. This class has been invaluable in teaching students a sustainable mindset and helping Rice-EWB to incorporate sustainable engineering into its service projects.

The third academic course created for Rice-EWB, CEVE 499: Special Problems - Introduction to Bridge Design, was created solely to support the Nicaragua Bridge team's efforts. The team approached the leaders of Rice-EWB and asked for specialized training in structural engineering and bridge design fundamentals. Rice-EWB then worked with the CEE department to create a student run independent study course which focused directly on the skills and knowledge the team needed to complete its project. Two upperclassmen CEE majors directed and taught the course with the support of several faculty members who gave guest lectures and offered guidance and supervision. The final project for the class was a preliminary design report for the proposed pedestrian bridge that would span a gorge in Nicaragua. Students responded very positively to the challenges this course proposed and worked diligently toward accomplishing the goals set out at the beginning of the course. Course reviews were very positive with many students stating that the class was their favorite class they had taken at Rice. This course succeeded in transferring the passion and excitement students have for their volunteer work on Rice-EWB projects into a classroom setting.

Rice-EWB and the CEE department are currently working to further integrate Rice-EWB into the curriculum by creating a series of permanent one credit hour courses designed to introduce Rice-EWB members, as well as students from across the entire university, to the innovative technologies, practical construction methods, and intercultural communication skills necessary to successfully take a project from the first community meeting, through engineering design, and to the actual implementation and construction. Because Rice-EWB members are from all majors, it is very difficult for students to take a time intensive CEE course which does not fulfill any degree requirements. Students have expressed a desire for hands-on, classroom instruction in the form of one credit hour courses that would meet once every other week for four hours in the evening.

The first proposed course, 'Innovative Water Purification', would devote each four hour class to a certain water purification method and would take students through the chemical or biological fundamentals of the method, system design and implementation, as well as system function and maintenance. Methods covered in the class would include chlorine, UV, ozone, slow sand filters, and Potters for Peace colloidal silver lined ceramic filters. The second proposed course, 'Practical Construction Skills', would dedicate each four hour class to a certain construction method or skill set in order to prepare students to work side by side with community members in constructing the engineering projects they designed. Construction practices covered would include concrete mixing and reinforced concrete design, masonry, water cistern construction, green building construction, photovoltaic systems and wiring, and PVC, plumbing, and drainage. The third proposed course, 'Intercultural Communication', would be created and taught by the Cain Project in Engineering and Professional Communication at Rice University. The course would consist of eight lessons in communicating across borders varying from explaining technical concepts through analogies to handling gender and age differences in intercultural settings. The class would focus on communicating in Rice-EWB's project countries, El Salvador, Mexico, and Nicaragua.

In order to recognize students for their work on Rice-EWB project teams and for their participation in Rice-EWB classes, Rice-EWB is exploring the possibility of creating a

'Certificate in International Engineering' that would be awarded to students who have satisfied a set of requirements involving Rice-EWB classes, international engineering and management classes, Rice-EWB project work, and extended travel to a foreign country. A certificate such as this would be the culmination of many years of hard work, and would recognize and reward students for pursuing and completing activities and classes which have prepared them to succeed in a global environment.

Rice-EWB has become a major component of the CEE department's goals for the future. The CEE department has realized the importance of experiential education and the value of international engineering experience, and has been very proactive in supporting Rice-EWB's efforts and in helping to promote and make available to its students Rice-EWB's hands-on, design based, international engineering opportunities. Rice-EWB is a key component of the CEE department's "Building Bridges to the 21st Century" National Science Foundation curriculum reform grant for 2005-2006. Through the implementation of service learning opportunities, Rice-EWB is promoting and making possible a transition away from the traditional engineering curriculum and into a new multidimensional and multidisciplinary curriculum that educators and industry both see as the future of engineering education. The department has also recently been reaccredited by ABET, and Rice-EWB was a major component of the evolution of the CEE department as well as a major focus area for future growth inside the department. Rice-EWB, for the last three years, has been leading a push towards integrating service learning into the CEE department and making available opportunities for Rice's engineers that have never been available before. In the coming years, Rice-EWB and the CEE department will work together to develop more ways to enhance the curriculum, assist project teams, and innovate new methods for introducing service learning and international engineering experience into the education of its students.

Rice-EWB is also leading the way in involving the Houston community in the education of Rice's engineers. Rice-EWB has brought education and industry together by creating several partnerships with prominent Houston engineering firms. Recently, Groundwater Services Inc. (GSI), a respected environmental engineering firm based in Houston, and TCB, a renowned multidisciplinary firm based in Houston which provides engineering, planning, and management services to clients across the country, entered into three year partnerships with Rice-EWB. Under these agreements, GSI and TCB will financially support a large portion of Rice-EWB endeavors as well as make available their outstanding engineers as resources for Rice-EWB students. Already, a GSI employee is the mentor for the Nicaragua water and energy project, and several other employees have offered valuable advice and mentoring. Rice-EWB is working on creating similar partnerships with two other highly renowned Houston based engineering firms. It is the goal of these partnerships to unite Houston's best engineers with Rice's best engineering students to create an environment where students can learn from Houston's leading engineers and where employer's can support and influence the development of engineers they may wish to hire in the future. This mutually beneficial relationship between industry and education is of paramount importance to Rice-EWB and will pave the way towards making a better educational experience for students and towards producing better qualified and experienced engineers for tomorrow's workforce.

Rice-EWB has also begun to reach out to the Houston charitable community as well. Rice-EWB has recently received a large grant from the Albert and Ethel Herzstein Charitable Foundations, one of Houston's largest and most influential charitable organizations, to support the work of the El Salvador Water Project. The foundation was enthusiastic about helping to reform engineering education, offer unique opportunities to students, and to serve a humanitarian cause. Rice-EWB has also received a donation from the Youths' Friends Association Inc. to help fund the activities of the organization and to promote engineering education. Rice-EWB hopes that these partnerships will continue to drive Rice-EWB to create projects and programs which will further a superior engineering education and which will serve worthy causes.

The support of Rice University and the Houston community have been essential in creating an organization that is capable of achieving its goals. Rice-EWB is committed to making worthwhile change in the developing world while developing engineers who are ready and capable of tackling the challenges of the twenty-first century. With the long-term support of the University and the Houston engineering and charitable communities, Rice-EWB will be able to offer unique educational opportunities for Rice's engineering students for many years to come.

**Overview of Projects**

Rice-EWB's international service projects drive the organization by providing engaging real-world projects for students to devote their time and passions. Rice-EWB currently has four international engineering service projects in three different countries. The organization is broken down into project teams who each devote 2 to 3 years to the completion of a specific project. These engineering projects, the communities Rice-EWB works with, and the technologies Rice-EWB employs form the framework for educational opportunities and the setting for all engineering experience earned. The following are brief summaries of the Nicaragua Water and Energy Project, the Nicaragua Bridge Project, and the Mexico Water project and a more detailed case study of the El Salvador Water project.

**Nicaragua Water and Energy Project**

In March of 2005, the newly formed Nicaragua Water and Energy team traveled to San Juan del Sur, a small city on Nicaragua's Pacific coast, and visited with several smaller communities in the surrounding areas to assess their needs and potential projects. In each community, the team spoke to community leaders and families, asking questions about water quality, status of wells and latrines, health problems, and building and electrical needs. After visiting many communities, the team decided to work with the community of Bernardino Diaz Ochoa. The town's main needs included a health center, expansion of their small school, electricity for community buildings, and a bridge for a nearby river to allow crossover in the rainy season. The community members also described many water-related health problems such as diarrhea. The team spent several days in the community, and took many survey measurements, water samples, health surveys, and developed a very strong relationship with the community. The team decided that the optimal project for their first implementation would be a solar powered power system to provide lighting for the community church in order to create a communal gathering place at night. The team traveled to the country in December of 2006 and successfully implemented a solar powered lighting system for the church that will allow for

community meetings and gatherings at night. While in the community, after performing a series of water tests, the team discovered that the community's drinking water was highly contaminated with both fecal coliform and *E. coli*. For this reason, the next stage of the project will be to drill a new community well and to implement a water purification system to remove all contaminants. Furthermore, the team discovered that the construction of a new building would allow for the creation of a regional health clinic that would serve the community as well as the 5 surrounding communities. Therefore, the another component of the second stage of the project will be to help design and build a small health center for the community. The team looks to complete these projects in the next two years.

**Nicaragua Bridge Project**

For the past two years, the Nicaragua Bridge team has worked on projects in the community of El Panama near Jinotepe, Nicaragua. During the team's first visit to the community in March 2004, the community members and the leaders expressed the need for a pedestrian bridge across the Aragon River to allow for safe crossing during the rainy season. The river, during high flow periods, separates the community from the schools, jobs, and emergency medical care that can only be found in Jinotepe. Another problem afflicting the community is a lack of potable water. The 50 family community relies almost entirely on a single well that only provides enough water to support half of the families. After obtaining EWB-USA approval for this project and acquiring the necessary surveying skills, the team returned to El Panama in December 2004 to conduct a detailed topographic survey of the future bridge site, take health surveys, and to investigate the community's sources of potable water. The members of the Nicaragua I team recently completed the CEVE 499: Special Problems - Introduction to Bridge Design course offered in the Spring of 2005, and have completed a preliminary steel truss design for the pedestrian bridge. In the coming months, the team will be working with structural engineering professors at Rice University to optimize and finalize the bridge design. The team is also working on designing a rainwater catchment system. The team will travel in March of 2006 to implement the rainwater catchment system and prepare for more work on the bridge.

**Mexico Water Project**

In May of 2004, the Mexico team successfully completed its first implementation trip in Piedritas, Mexico. On the seven day trip, the team installed a powerful solar powered water pump in the community's water well as well as a PVC water distribution system. The new water pump increased the well's flow rate three fold, drastically increasing the community's available water supply. The installation of a distribution header allowed for water to be piped to each of the houses in the community. These improvements increased the availability of water and the ease of access to water. After completing the first phase of the project, the team decided to focus on designing and implementing a purification system to address the water contamination issues in the community. The community's water is highly contaminated with bacteria and has an elevated and unhealthy level of fluoride. The team is currently in the process of designing a trial sand filtration system for the community's school that will disinfect the water and remove the fluoride. The team will install the trial system in the spring of 2006, and if the trial system succeeds, the team will look to implement the solution across the community in summer of 2006 or winter of 2007.

**El Salvador Project**

The San José Villanueva Water Project began in January of 2004 when three students first met with community leaders to discuss collaboration on a water project designed to provide water storage, distribution, and purification for 700 Salvadorans who relied on a single spring for all of their water. The aim of the project was to increase access to water and to improve the quality of that water. Before the implementation of the project, the community had one open pipe for drinking water and clothes were washed on a rock. There was no water storage, and people

Figure 1: Project site before arrival

often waited in line for over an hour to obtain the smallest bit of contaminated water. As a result of the contamination of the natural spring source, the community was experiencing the worst water related health problems in the municipality.

In May of 2004, seven students traveled to El Salvador to obtain precise survey data, take water tests, and prepare for implementation. Once back on campus, Rice-EWB members designed a water system that fit the community's needs and wishes.

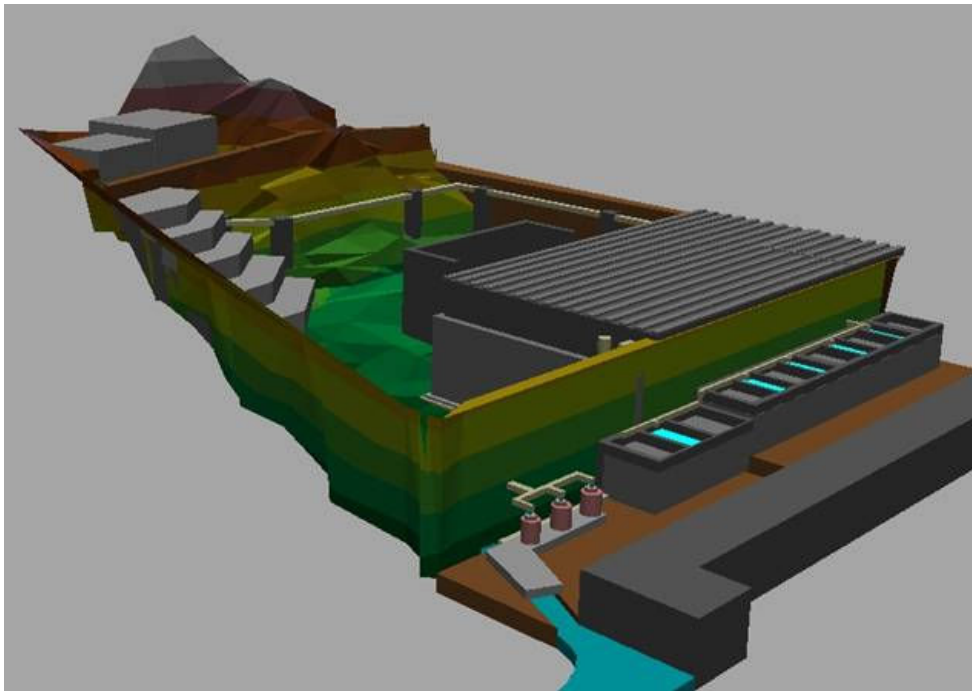

Figure 2: 3-D model of project design

In January of 2005, seven students and their mentor returned to El Salvador to implement the first phase of the project. Over a period of 17 days, Rice-EWB members worked side by side with community members to construct a 40,000 liter reinforced concrete cinder block storage tank, 7 washing stations, 3 drinking water taps, and a bathing area. Students also worked to

Figure 3: Completed washing stations and water storage tank

organize and empower the community and to prepare them for managing and maintaining the system. Implementation was a success. The system functions as planned and people are using the washing stations and drinking water taps throughout the day. Wait times are reduced and access has been greatly increased.


Figure 4: Washing stations and bathing area in use

The El Salvador team then began work on the second phase of the project which centered on water purification and solar powered lighting. After a long period of research, the team decided to implement an in-home colloidal silver lined ceramic filter purification project. The team also worked throughout the year designing and testing a solar powered lighting system to provide light for the washing stations and drinking water taps at nighttime in order to make the area more secure and to increase accessibility. The team returned to San Jose Villanueva for 10 days in January of 2006. During this implementation trip, the team successfully installed solar-powered lighting at the project site.


Figure 5: Solar panels and project team

The team also subsidized and organized the purchase of in-home purification systems for two hundred homes, or over one thousand people, throughout the region. Potters for Peace colloidal silver-lined ceramic filters were acquired from factories in El Salvador and Honduras, and were sold, at a subsidized price of six dollars, to over forty families during the trip. Rice-EWB provided an additional one hundred and sixty subsidized filters to the local health clinic to sell and distribute across the community in the coming months. With a lifetime of two years, the colloidal silver lined ceramic filters cost only three dollars per year, and produce filtered and disinfected water for an entire family. Rice-EWB is working to arrange for the subsequent purchases from the filter factories that will take place every two years.

Figure 6: A Potters for Peace filter and a family with their filter

The January of 2006 trip signified the completion of the San Jose Villanueva Water Project. In two years, the El Salvador team has designed and constructed a water storage tank, washing stations, drinking water taps, a bathing area, a solar powered lighting system and has implemented a region wide water purification campaign while simultaneously creating a lasting and influential relationship with the community of San Jose Villanueva. The project, over two years, cost only twenty five thousand dollars (seventeen thousand dollars of which were for travel expenses) yet had a tremendous effect on the health and quality of life of over seven hundred people. From the five trips to the country, students have become comfortable and adept at dealing with the differences between El Salvadoran culture and American culture, experienced in construction and international project management, excellent leaders, and have had a tremendously rewarding and exciting experience in the process.

**Conclusion**

In its three years of existence, Rice-EWB has worked with the CEE department to create unique opportunities for Rice's engineering students, and in the process has played a major role in integrating service learning and experiential education into the engineering curriculum at Rice University. With dual goals of improving quality of life in the developing world through the

completion of sustainable international engineering projects and training and creating engineers for the twenty first century, Rice-EWB is revolutionizing the approach to engineering education and making Rice University a unique, exciting, and innovative place to pursue an engineering education.

1. Challenge. Engineers Without Borders – USA. 12 Jan. 2006 <http://www.ewb-usa.com/modules/context/index.php?id=43>.