

AC 2009-484: SUSTAINABILITY AND IMPACT OF GLOBAL PROJECTS

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Sustainability and Impact of Global Projects

Abstract

A Global Projects in Engineering & Technology course at Brigham Young University has been in existence for three years to broaden the learning experience of engineering students by solving real-world engineering challenges using multi-disciplinary teams. The first two classes involved projects implemented in Tonga (2007) and Peru (2008). With the class currently in its third year, it was important to assess the sustainability of previous projects and the impact of the projects on the local people. All of the projects completed previously, and the projects currently in development, involve technical processes.

Studies were conducted to assess the sustainability, cultural response, and effectiveness of the humanitarian engineering projects completed by the students. The studies were conducted, and conclusions were drawn, based on student survey results, local villager responses, personal interviews, and discrete observations. Several studies were conducted both during the project implementation trip and several months following the trip.

Student surveys conducted during implementation of the projects showed that the perceived response was very positive and that the villagers accepted and would continue to use the projects. In terms of maintaining the technology, however, the students were more skeptical of the ability of the villagers to maintain the technology. Personal interviews with the villagers showed that they were very grateful and excited to see how these projects would help them to receive the basic needs of life. Acceptance level of the projects usually depended on the technicality of the project or process being implemented. Overall, the more technically complicated a project was, the more difficult it was for the people to understand, maintain, and use. Upon post-implementation follow-up, this observation was confirmed as the more complicated projects were usually abandoned, while the simpler, more basic projects were still in use for months after the original implementation. The simple projects passed the “walk-away test,” while the others did not. Another factor in the acceptance level of the projects was whether the projects proposed a solution to a perceived need, or was an actual need.

Projects selected in the future should focus on finding simple, less technical solutions to actual local needs as received from the villagers. Ideally, this would entail much more involvement from the selected village throughout the entire design process to ensure that the final solution would be useful and locally accepted. Projects should also be easily developed and tested prior to the implementation trip.

Introduction

Engineers Without Borders (EWB) is an international organization whose mission is to provide humanitarian aid on an international level and increase the standard of living through engineering solutions. In 2006, a new chapter of EWB was founded at Brigham Young

University. Once the chapter was founded, faculty advisors and student officers implemented a technical elective course that was focused on the creation and implementation of humanitarian engineering projects. The course was titled *Global Projects in Engineering and Technology*. Details of the original course, along with the purpose of the course, were previously presented.¹

During the fall (2-credits) and winter (1-credit) semesters, students are given a particular project idea to pursue for implementation in a third-world country. The students are divided into teams of five to six students to work on separate projects. Throughout the fall semester, there are numerous presentations, reports, and assignments to make certain that the projects are on schedule and are feasible. At the end of the fall semester, teams present their work and their proposed solution to the faculty and students. The following semester is used to optimize and test the projects, as well as learn about the particular local culture where the projects will be implemented. At the end of the winter semester, students have the opportunity to travel with the class to the location where their project will be implemented; they will receive firsthand international experience and learn about the difficulties and challenges of implementing international engineering projects.

This class, which is currently in its third year, has received immense support from the college and the university. Funding from the college typically supports about one-half of the student travel costs. There is also a high level of interest in the class among the engineering students. A typical class is composed of approximately 30 students with an equal mix from Chemical, Civil and Environmental, Electrical and Computer, and Mechanical Engineering Departments. About two-thirds of the students participating in the class go on the international trip.

Each year, students are given the opportunity to give feedback on the class and the implementation trip. Based on feedback, the class is then modified and improved for the following year. Several key course changes have included:

- Brainstorming and Leadership sessions at the beginning of the semester
- Team teaching of engineering concepts to other teams (since not all students are in the same discipline)
- In-class exams on engineering concepts applied to the projects
- Mid-semester requirement of prototype demonstration
- End-of-semester technical report written in the format required by the national EWB organization.

One key aspect missing from the course and trip assessment was an extensive assessment of the sustainability of the projects, particularly from the individuals in the countries where the projects were implemented. The mission of this class is to not only provide students with an educational engineering experience involving international work, but also to create projects that are sustainable and that will actually make a difference in the communities where the work is being implemented. This paper will focus on the sustainability of the previous projects completed in Tonga (2007) and Peru (2008) and gives recommendations for the types of projects that should be selected in the future as well as how they should be implemented.

Tonga

Project Description

The first project that was undertaken by the class was to design a process that could be used in the Kingdom of Tonga to extract the oil from a coconut and convert the oil into biodiesel. A substantial amount of research was available for the process of converting vegetable oils into biodiesel, as well as the process of extracting the oil from coconuts. The purpose of this project was to combine the two processes and show how simple biodiesel production could be implemented in Tonga.

Students were divided into six groups that each focused on one specific aspect of the process: oil extraction, conversion to biodiesel, separations following conversion, waste management, added value (such as soap), and economics. Throughout the school year, these teams worked together to research, develop, and test their assigned processes. In May 2007, the students traveled to Tonga to set up a biodiesel reactor and demonstrate the process to local leaders.

Assessment Process

Assessment information was gathered by pre-trip and post-trip surveys. These surveys showed the student's responses about how the class was run as well as the social and technical challenges of implementing the project. Students also were asked about their abilities to solve open-ended problems and the educational benefits of international humanitarian projects. In Tonga, many observations were also made by the faculty and students. Observations were made throughout the entire process; these observations showed the general feelings of the local people involved in the project implementation.

Assessment Results

The results of the assessments were very insightful; together, the combined student responses provided a well-documented record of the successes and challenges experienced in Tonga. Once in the country, the students began to realize that implementing the project in Tonga was more difficult than what was practiced in the classroom. One major issue was the availability of supplies in Tonga. Several items were ordered and shipped to Tonga although the shipping was not consistent. Some items were still not present upon arrival in Tonga. Although arrangements were made ahead of time, there were also many unanticipated taxes and tariffs on the equipment and supplies. However, by the end of the trip everything came together and the students were able to demonstrate the process of making biodiesel to government leaders and local school groups. The biodiesel reactor was also left with an individual in Tonga for continued use.

Upon implementation, the local response was very positive. Newspaper articles were written and a three-minute interview was shown on Tongan television. Among the twenty-one government leaders that attended the demonstration were the ministers of agriculture, tourism, and foreign affairs; one of the princes of Tonga was also present. After the demonstration, many of the government officials were very optimistic about the possibilities of making biodiesel in their country using local resources. In the student surveys, there were many comments about the

project successes; one student said, "...the [project was] well received by the people and the government officials." Another stated, "It was an amazing experience to give presentations to the [government] ministers of Tonga." General comments regarding social challenges ranged from a) "The people were very easy to get along with, so I guess my biggest social challenge was not having everything at my convenience (stores, food, supplies). The food was also hard to get used to." to b) "Dealing with the Tongan "gift culture", trying to give them gifts and getting so much in return! I felt so guilty, as these people did not have much, yet they were willing to give all that they had."

Although the response was initially very positive, the biggest concern was whether or not the people would be able to maintain the project and create biodiesel after the students had left. This concern was mainly due to the complexity of the process and the need to have specific training on the process for it to run smoothly. After the students had left the country, the equipment and supplies were left in Tonga with the hope that production would continue. The two people who had been trained to run the equipment did run one or two 40 gallon batches of biodiesel, but they called from Tonga in order to clarify many technical aspects of the project that they did not fully understand. Soon after these batches were run the excitement died down, and the equipment was put into storage. One of the largest impediments to the continued sustainability of the project was the necessity to import methanol, which is one of the key constituents of the biodiesel process. As one student wisely stated, "The best technology, and even the best intentions, do not always yield the desired results."

Sustainability Summary

In terms of sustainability, the biodiesel project would have been more sustainable if the local people in country took ownership. It would have been better to work through a local NGO (Non-Government Organization) that already had local contacts and people in-country who were working with certain communities. The Tongan that the students worked with lived in the United States and therefore was not continually in country. The original idea was that the local people would continue making biodiesel to reduce the cost of fuel on their island. It seemed initially that the people were excited, but they never took ownership. Part of this was due to the fact that the end result of the project was a demonstration. The local people found the project interesting, but they still viewed it as belonging to someone else.

Another factor that affected the sustainability of the project was the nature of the project and the way it was designed. This project focused on a process more than a product. The process was fairly complicated, and due to this fact, it became very difficult to train more than a few people on the correct procedure. The problem arises if those people do not fully understand the process and do not see its potential. This became manifested after the students had left the country; the two Tongans who had been trained to use the equipment were still unsure about some technical aspects as shown by their phone call from Tonga.

On a more positive note, the project was very successful in impacting the traveling students. As one student explained, "At first I was only interested in the class because they were going on a trip to Tonga, however, participating in this project has led me to the realization of how *my* unique skills, and *my* contribution can really affect the world around me." Students said that

some of their biggest rewards from the class were “Making decisions, moving forward and seeing it all come together!” and “Making *real* progress by overcoming challenges that at first seemed hopeless”.

Peru

During the second year of the class, new projects and a new location were selected. Previous to the beginning of the school year, the course instructors, along with one student, traveled to Cuzco, Peru to perform an assessment trip. The purpose of this trip was to see firsthand where the student projects would be implemented and to meet with village leaders to determine the true needs of the people. The assessment trip was one key improvement from the previous year. An additional key aspect of this project that was different from the Tonga project was that the projects were completed through an NGO. Once the assessment trip was completed and the necessary information had been gathered, the engineering projects were identified. The projects focused on water distribution, water storage, water heating, cooking stove design, and biogas production. Once class began, the students were divided into teams of five or six for designing and testing the projects.

Project Descriptions

The students in each of the groups were free to design a process that would meet the specifications of the identified projects. The Water Storage team designed a system to store spring water for use during the dry season and to cap streams going into the storage system; the Water Distribution team then designed how they would get the water from the storage tanks to a centralized location where the people could have easy access. One major problem faced by the people was the lack of smoke ventilation and poor heat containment of cooking fires in enclosed kitchens. The Cooking Stove Design group worked to design a more efficient cooking stove with good ventilation for the people to improve their living conditions. Finally, the Water Heating group sought to determine the best way to heat water for home use, and the Biogas Production group designed a small-scale biogas reactor that would take local llama dung and convert it to methane. At the end of the school year, these students felt that their projects had been tested enough to be able to implement them in a local village near Cuzco.

Assessment Process

Prior to the implementation trip, a written assessment of the students was performed to determine how difficult it was to gather the necessary information to complete their projects. This information was documented and compiled in order to determine where the greatest difficulties were in the project design process. Some of the questions addressed such things as the difficulty of determining the needs of the villagers and the difficulty of obtaining technical information about the project location.

Once the students were in the country, one student spent 12 hours interviewing the local villagers in their native language and documenting their responses on camera. These responses were compiled into a video showing the general feeling of the villagers after the implementation.

Other observations were also made about the overall response to the projects and these were documented as well.

Observations made by other students on the trip were recorded in a post-implementation written survey which the students completed just after the projects were completed. This survey focused on the response of the local villagers to the projects implemented. Questions were asked about the likelihood of the villagers continuing to use the specific technology once the students had left and the ability of the locals to maintain these new technologies. A few months after the trip, several students and the course instructor contacted the NGO with whom they had worked to determine the success of the projects once the students were no longer in Peru.

Assessment Results (Pre-trip and during trip)

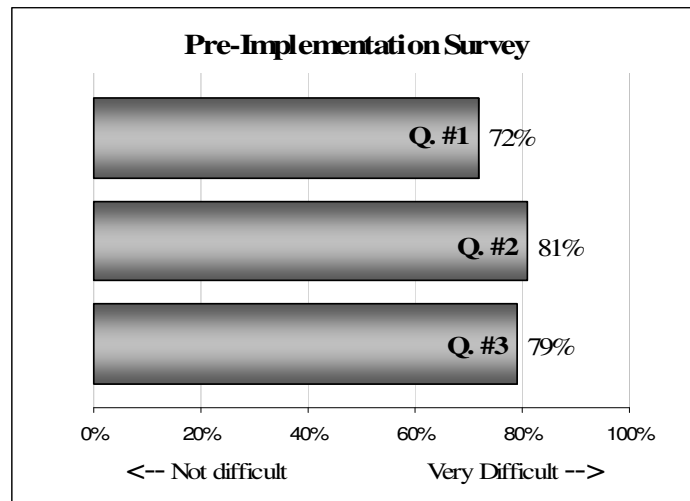
During the pre-implementation survey, students were asked:

- Question #1- How difficult was it to determine the needs of the villagers?
- Question #2- How difficult was it to obtain technical information about the project location?
- Question #3- How difficult was it to communicate with the village leader?

As can be seen from these survey results, the students felt that it was very difficult to communicate with the local leaders to determine the needs of the people and to obtain technical information required for the project (such as stream locations, water flow rates, etc.).

Upon arrival, all of the projects were implemented; however, many of the projects had to be adjusted based on the local materials available. Materials which students had been told would be available were actually difficult to find.

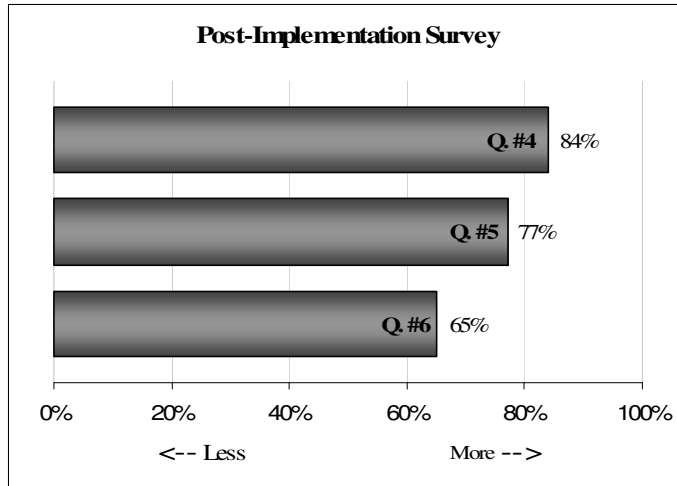
This was probably due to miscommunication between the NGO contact and the engineering students.



Most of the interviews conducted showed that the people were excited and grateful for the projects; however, when asked about how the projects worked or whether they felt that they could maintain them, the villagers did not feel confident. All of the villagers that were interviewed, however, did see the need to improve their living conditions. Unfortunately, with the exception of the village leaders, many did not understand how some of these projects would directly impact them.

After the implementation was complete and the students were preparing to return home, they completed the post-implementation assessment. Some of the questions on this survey were:

- Question #4- How well did the local people accept the projects?
- Question #5- What is the likelihood that the villagers will continue to use the technology once the students have left?
- Question #6- Did the locals have a good idea about how to maintain the new technology?



As shown, the people seemed to accept and be grateful for the projects that were completed, and while the students were optimistic about the villagers using these new technologies, they were skeptical of the villagers' abilities to maintain the projects.

Some of the students also said in the survey that the villagers were "...anxious to see [the projects] work and to see results." Another student commented that the locals "...appreciated the new technology, but they weren't exactly sure how it worked."

Sustainability Summary

A few months after the trip, the NGO was contacted to determine the success of the projects once the students were no longer in Peru. Some projects, like the stove design and water storage, were successful and continued to work after the students had left the village. These successful projects required very little, if any, technical understanding. The water distribution system was still functional but was modified after the students left. The local villagers were not aware of the importance of some valves and they modified the system after the students left. One major problem was that no written documentation regarding the design was left with the people. The water heating system worked for awhile but then the copper tubing (which was the heat exchanger) ended up melting. This project is being fixed with a new design this year. Finally, the biogas reactor was not touched once the students had left. This reactor did not work for a variety of reasons:

- The process required specific equipment to collect data and analyze the process
- The design concept was more than what most of the villagers could understand
- No one had been well trained on the process or how to make necessary adjustments

As noted, the initial response of the people was very positive, but the true test came after the students had left. The reasons behind the failure of some projects and the success of others included the ability of the students to communicate technical information and the ability of locals to understand, utilize, and take ownership of these projects. As mentioned above, interviews were conducted with some of the villagers and their leaders; these interviews showed that the people in general were very excited and grateful that the students were there. Many of the villagers, however, did not fully understand the projects that were being implemented, and in

some cases, they didn't really know what the students were doing—even though the projects were discussed with the local leader. This could have been due to the low education level of the people living in the village, or simply that the students did not take enough time to explain the details of the project to the people.

The sustainability of the projects implemented in Peru was measured by observing what projects lasted, and what projects did not. The three key factors in deciding whether or not these projects lasted were:

1. Could it pass the “walk-away test” where the creator of the project can “walk away” from the project and the project will still function and work successfully?
2. Was it based on a true need or a perceived need?
3. Was it too technically complicated for the people to understand?

By asking these questions about each project implemented, one can determine the overall sustainability of the project. The improved stove design was a project that continued to function after the students left, was based on a true need, and was very simple. It was constructed using local materials and a design that the people were comfortable with. There was also a visible improvement as the homes no longer filled up with smoke when a cooking fire was lit. The water collection and distribution projects were much needed; they also passed the “walk-away test,” but once the people began to open and close valves, the technical complexity became too much for the people. This caused the system to stop working and resulted in modifications that affected the original design. The biogas reactor did not pass the “walk-away test,” was based on a perceived need, and was far too technically complicated. The students had to try to convince the people how good it would be to have a biogas reactor, but unfortunately, they did not need it and did not understand it.

This year, a new team of students will travel to Peru to improve the designs previously implemented in this village. Students involved in the follow-up trip have not only studied the previous projects and determined what did not work, but they have redesigned some of the previous projects to create a better solution.

Recommendations

The task of designing and running a new class that focuses on humanitarian engineering projects is monumental. Planning and preparation is crucial, but almost as important is the assessment of how things have gone in the past in order to improve them for the future. The assessment of the first two years of the *Global Projects in Engineering and Technology* class has greatly assisted in selecting projects for the current class. Based on the assessment, the following guidelines have been established for selecting future projects such that projects:

- are properly identified during an assessment trip with the local people
- focus on a product, not a process
- focus on a *true* need, not a *perceived* need—the project should be something the local people want, not what students at a University want

- are not something too technically complicated for the people to understand—a self-explanatory document for each project should be left with the people
- are completed in partnership with a trusted NGO (or local contact) that is located in the country and is already working with the particular community
- are thoroughly tested prior to implementation
- pass the “walk-away test”

Future projects should be well-tested before they are taken to a humanitarian situation— if it doesn't work in the lab, it won't work in the field. For instance, the biogas reactor was tested at a small scale at the University but the process required several months and a larger scale was never tested. If a particular class project is not ready to be implemented by the end of a school year, it should be reworked and improved during the next year's class until a finished product is complete. In order to be able to fully test a project, it must also be something that can be entirely built and tested in a lab at the University. A solar project is an example of a project that is difficult to test since solar conditions are usually different at the University as compared to the country of implementation. There are humanitarian projects, such as a water distribution system, that are also difficult to implement since thorough testing cannot be completed until in the country of implementation.

Although projects have succeeded and failed since the inception of the class, this class has taken a significant step forward since its conception. Students who have taken the class have enjoyed the opportunity to use the concepts they learned in engineering classes to help those in developing countries. For many students, it has been a life-changing experience. As the projects selected are more sustainable, they will be able to meet the true needs of the local people, provide students with the chance to apply their engineering knowledge to real-world situations, and help students gain meaningful international experiences.

References

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