Lessons Learned From An International Service Learning Project

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Introduction

In May of 2004, a group of students from the Valparaiso University chapter of Engineers Without Borders (EWB-VU) undertook a trip to the village of Nakor, Kenya with the goal of constructing a water supply and irrigation system they had designed. While the project was successful, numerous problems were encountered in its implementation. These challenges resulted in the group learning several important lessons, which will not only be applied to future trips to the village, but can also be applied to other international service projects.

After a brief explanation of the goals and philosophies of Engineers Without Borders, a description of the project and its implementation will be provided. The project description will be followed by a discussion of the lessons learned and a description of the manner in which these lessons will be applied by EWB-VU during future trips to the village.

Engineers Without Borders

The project described in this paper was conducted under the auspices of the Valparaiso University Chapter of Engineers Without Borders. With its national headquarters in Colorado, Engineers Without Borders (EWB-USA) is a non-profit organization established to help people in developing areas worldwide with their engineering needs by involving, and simultaneously training, internationally responsible engineering students. EWB projects typically include the design and construction of water, wastewater, water purification, sanitation, energy, and shelter systems. Projects are initiated by, and completed with, contributions from the host community, which is then trained to operate the systems without external assistance.

Because EWB projects are intended to be self-sustaining, they are designed to be as simple as possible. Utilizing a simplistic project design facilitates the transfer of knowledge of the project construction and maintenance to the local people, who often lack even the most basic mechanical training. Additionally, the projects emphasize the use of materials that are available to the local people. This is done to simplify the maintenance of the project should replacement parts become necessary and simplify its reproduction should a nearby community desire to replicate the project. This transfer of technology to the local people and the use of locally available materials are key elements to the EWB philosophy of sustainability.

The Project

The village of Nakor, in Northwestern Kenya, is approximately 70 miles (a 2 ½ hour drive) southwest of Lodwar, the nearest town large enough to contain stores where project materials are available for purchase. The village consists of approximately 2300 people spread out over approximately 20 square miles and is located in the Turkana region, an area that has been severely affected by drought. The region receives an average annual rainfall of less than three inches and, although the village is located along the Kerio River, the river typically flows less than one month a year.

Traditionally, the drinking water supply of the village has been obtained primarily from relatively shallow, hand-dug, open-pit wells in the riverbed. The water is carried, often by children, in five-gallon containers from the well to the household, a distance as great as four miles. Unfortunately, these wells are also used for watering goats herded by the villagers and quickly become fouled by animal waste. Additionally, there was no long-term water collection or storage, and consequently, no irrigation of cropland.

Although the Kenyan government and various international aid relief agencies sporadically finance corn subsidies to the Turkana people, famine and malnutrition are common. The staple of the Turkana diet is the palm nut, a fibrous material with low nutritive value. The death rate of children below the age of five years is near 40 percent, due primarily to malnourishment and water-borne illnesses.

Gene Morden, who, along with his family, has served as a missionary in the Turkana region since 1995, brought the need of the Turkana people for clean drinking water and water for irrigation to the attention of EWB-USA. EWB-USA awarded the project to EWB-VU in October of 2003, a mere eight months before EWB-VU took their first implementation trip to Nakor. EWB-VU has planned three trips to Nakor: the initial trip in 2004, and subsequent trips in the springs of 2005 and 2006.

Initial Planning and Preliminary Design

Initially, the scope of the solution proposed by EWB-VU consisted of two components intended to address the drinking water and the irrigation/food needs of the village. The proposed components were:

1) Windmill-Powered Water Pumps: Gene Morden reported that the groundwater in the area was potable and relatively shallow (less than twenty feet below the ground surface) near the river but deeper (between 80 and 100 feet below the ground surface) near the village center, which is situated on a bluff above the river. It was decided to install one well near the river and a second well near the center of the village in order to provide drinking water for the village, and eliminate the long walk to and from the wells in the riverbed. By installing the windmill-powered wells, the problem of contamination of the water by animal wastes would be virtually eliminated, as the water would be pumped straight from the aquifer.

2) Water Storage for Crop Irrigation: In addition to providing drinking water, it was decided to investigate the feasibility of an irrigation system to aid in food production. The community had

selected a plot of land near the river for this communal garden; unfortunately the soil at this location, while arable, was not cultivatable due to the arid climate. The goal of the second component of the project was to establish a small (roughly one acre) test plot watered by a drip irrigation system, which would consist of the irrigation tubing itself, a water storage tank and a windmill-powered well to feed the system. If the test plot proved successful, EWB-VU would expand the irrigation system from one acre to approximately 20 acres of cropland during subsequent visits to the village

During the planning and preliminary design phase, design and planning were performed based upon the information and data available through correspondence with Gene Morden and by conducting research on the region and the proposed systems. Groups were formed within the EWB-VU chapter to investigate the areas of pump design, water sanitation and distribution, travel and logistics, and financing for the $45,000 project.

Site Reconnaissance

In March of 2004 a site reconnaissance trip was taken to the village of Nakor by the first author and Chris Breinling, a senior civil engineering student at Valparaiso University. The purpose of this trip was to perform an initial survey of the area, assess the needs of the community, and determine the availability of supplies. During the trip, the groundwater was tested and found to be of good quality when it was collected directly from the aquifer.

By holding meetings with the local community, it was determined that the lack of food sources in the region was of greater urgency to the local people than the quality and quantity of the drinking water available. This was a shift of focus from the initial perspective held by EWB-VU, which had placed a higher emphasis on drinking water supply.

Additionally, while on this trip, arrangements were made with a Kenyan drilling company to drill the well in the village center. The fabrication of three windmills was arranged with a welder in Lodwar, and locations for the windmill placements were finalized.

Design

Following the site reconnaissance, design of the system began in earnest at Valparaiso University. Due to the short time frame (mid-March to mid-May) and the still limited information on the availability of supplies, site conditions, and quantity of local manpower available, the design work was limited to preliminary plans, with the understanding that modifications would made as needed in the field during construction.

Approximately two weeks before the planned visit, EWB-VU was informed that the drilling company had pulled out of the project. As a result it was decided that an attempt to drill the well to be located in the village would be made with the equipment available, a small drilling frame powered by a lawnmower engine. This shift in plan would prove to be a significant, yet fruitless, drain of resources and manpower.

Construction

During the second half of May, the EWB-VU project team consisting of the first author, his wife, an African history professor and twelve Valparaiso University students (including the second author) traveled to Nakor, Kenya to implement the project. The twelve students included five civil engineering majors, four mechanical engineering majors, two social work majors, and one history and music double major. Once in the village, the team was supplemented by the Mordens, the Matterns (another family of missionaries in the region), and three Turkana translators. Nine days were spent in the village of Nakor working together with the local people, although no work was performed on Sunday in accordance with the wishes of the missionaries.

Beginning almost upon the group's arrival in Kenya, unforeseen challenges arose which required adaptability on the part of the project participants and the re-design of certain project components. In addition to the cancellation of the drilling contract, the 4000-L tank intended to store the water pumped by the well in the village center was damaged en-route to the village. Then, almost immediately upon arrival in the village, many members of the group were infected with a severe form of 24-hour stomach flu that one of the students had brought with them from the United States. This illness led to a significant decrease in the available workforce, as it typically sidelined each recipient for one to three days.

As previously discussed, the group initially planned to install two well-and-windmill systems in separate locations, one near the river to provide irrigation and drinking water, and one near the village center to provide easy access to drinking water. The well in the village center was scheduled to be drilled by professional drillers due to its anticipated depth of over 80 feet. Following the cancellation by the driller, the group attempted to drill the well using an available drilling frame powered by a lawnmower engine. This effort failed due to a lack of power in the rig and an inability to drive the casing necessary to keep the borehole open. After several days effort it was decided that the effort would be repeated in 2005 with more adequate equipment.

At the river site, the local people had used an auger to drill a well to a depth of 23 feet before the group's arrival, but the well had not been developed or connected to the windmill. Unfortunately, problems developed when the well was connected to the windmill. Initially, a sufficient vacuum could not be produced to lift the water from the well due to the poor quality of the available pipefittings. Once the vacuum was established, the foot valve had to be removed from the wellhead because it repeatedly became plugged with silt, causing the pump to cease drawing water from the aquifer. It was eventually decided that, although its removal made priming the pump significantly more difficult, it would be best to remove the foot valve as it would likely continue to plug in the future, rendering the irrigation system inoperable.

Implementing the irrigation system involved drilling holes in several thousand feet of half-inch diameter ABS plastic pipe, constructing a manifold for the system, digging trenches, and laying pipe. In order for the irrigation system to become operational prior to the group's departure, the decision was made to reduce the size of the plot from its planned one-acre size to one-quarter acre. This decision was made largely due to the reduction of the labor force resulting from the illness that affected many group members. Although this change had to be made, the irrigation plot was built in such a way as to make future expansion possible. Other changes made to the initial irrigation plot

design included altering the depth of the trench that the drip lines were to be laid in, and changing the method of sealing the ends of the drip lines. After consulting with Gene Morden, who holds a masters degree in agriculture, the depth of the drip line trenches was changed from six inches to two inches and a folding method was employed to seal the end of the drip lines.

Lessons Learned

The mixed success of the project lead to numerous lessoned learned which will be applied to the later stages of this project and are also applicable to many overseas (and many domestic) service-learning projects. These lessons can be roughly categorized into the importance of a reconnaissance trip, project organization, communication, the need for pre-trip education, the presence of non-engineering majors, tools and materials, and perhaps most importantly, the need for flexibility.

The Importance of a Reconnaissance Trip

The importance of a reconnaissance trip cannot be over emphasized. It should be performed as early as possible in the design process as it is the main source of information, data, and design criteria. In addition to obtaining design data, the reconnaissance trip is critical for:

- Establishing a relationship with both the local people and the local contact person
- Determining a practical scope for the project
- Determining travel and lodging logistics
- Determining the availability and cost of the materials necessary for construction
- Making arrangements to hire translators

Project Organization

Thorough organization of project work before arriving on site will make the implementation trip progress more smoothly. A detailed plan must be developed for how the construction of the project will be approached, and this plan must be clearly expressed to the project participants. Similarly, work assignments should be determined beforehand in order to allow for training of the workers.

For the EWB-VU project in Nakor, Kenya, it was initially planned that each project participant would take a turn working on each portion of the project. This plan was disrupted due both to illness and the varied level of technical skills of project participants. In the future phases of the project, each student will be designated to work on certain tasks of the project, so that they will become knowledgeable about their specific area of the project and be able to more successfully see it through to completion.

Communication

Communication is a critical aspect in determining the success or failure of the project. Frequent communication must be maintained with the contact person of the host community prior to travel to

the site, within and between groups working on different aspects of the project, and within the group as a whole during the visit to the site.

Communication with the local contact person is critical to success, especially before the site reconnaissance trip. The local contact will serve as the engineers' main source of information. It is this information that will tend to establish the project's scope of work. Maintenance of communication remains critical between the reconnaissance and construction trips in order for the designers to remain abreast of changes in conditions, such as the loss of the drilling contractor. While communication with someone in a developing nation can be challenging, the growth of the Internet and widening of cell phone coverage have made it somewhat easier in recent years.

Groups working on the various aspects of the project need to communicate their ideas with each other in order to work effectively. As the trip progressed, it became clear that many members of the team were having difficulty understanding the project as a whole, and what the various teams were doing. This was due chiefly to problems communicating ideas and information both between the various groups and between the project leaders and the project participants. It is important that groups working on different aspects of the project be provided with updates on the work of each group so that they can have an idea of the overall status of the project. It is also essential for general project participants to be instructed on their particular role in the project and what is expected of them, so as not to cause confusion or disagreement during the project. By keeping this communication open, each project participant will form accurate expectations for the trip, which are vital to the success of the project.

Once the group arrives at the project site, the need for communication does not lessen. The project undertaken was spread out over many square miles, making communication difficult. Because the teams lacked radios, it became necessary to drive from site to site to confer with the other teams.

Additionally, translators were necessary to communicate between the project group and local people, as very few of the natives spoke English and none of the EWB-VU project team spoke Turkana. To overcome this obstacle, in addition to the missionaries who all spoke fluent Turkana, EWB-VU was able to hire three translators from Lodwar. The presence of multiple translators is critical when multiple groups are working in multiple locations.

The Need for Pre-Trip Education

During the trip the lack of hands-on technical skills among many of the project participants quickly became apparent. This was a factor for both the engineering and non-engineering majors. While some were strong in the theoretical design and functioning of water systems, most students lacked practical training in the nuts-and-bolts construction of such systems. Prior to future trips, additional training for the students will be provided in the construction-oriented aspects of the project, such as the installation of pumps and the drilling of wells.

Presence of Non-Engineering Majors

A pleasant lesson learned on the trip was the value of the presence of the non-engineering majors on the trip. While the engineering students and professor tended to focus predominately on the

engineering aspects of the project, the non-engineering students and professor tended to also consider the social impacts of the project. They helped the project team to recognize the importance of building relationships with members of the host community, to take the local culture into consideration, and to think more deeply about the long-term sociological affects of the project. This broader vision served to make the project more meaningful and educational for all who were involved, both members of our project team and the local people.

Tools and Materials

A major problem encountered on the trip involved the quality of supplies and equipment purchased and utilized in the Kenya. The quality of the materials purchased in Kenya for the project did not always reach the standards of American production quality, which made efficient completion of project tasks difficult. The Chinese metal fittings and valves were especially troublesome due to their poor quality, which made sealing the pumping system sufficiently to create a vacuum a continuing problem. The available tools were adequate, but could be improved in order to accelerate the implementation of the work. Additionally, better metal working tools would have been helpful, especially those used to cut shapes out of steel plate.

More plentiful and higher quality hand tools, including shovels, pick-axes, wrenches, and clamps, would be beneficial to future projects. These may have to be purchased in the United States and transported to Kenya. Metal valves and fittings could also be brought from the United States, although this would be complicated to coordinate, as project needs (such as the size of pipe utilized) will likely deviate from the original designs.

The Need for Flexibility

Undoubtedly the largest lesson learned during the trip to Nakor was the need for flexibility. While construction of such a system in the United States would undoubtedly encounter unforeseen problems and complications, facing setbacks during construction in a developing country, seventy miles from the nearest town can be almost overwhelming.

Paradoxically, while the need for a more specific and detailed work plan has already been identified as a lesson learned from the trip, the need to be able to deviate from that plan proved an even more important lesson. Between the loss of the drilling contractor, the damaging of the 4000-L tank, the illness encountered by the travel group, and the changes in materials and conditions, the project work deviated greatly from the scope and work plan initially developed. These changes required the need for almost constant flexibility of work plans and assignments. While it is important to have a clearly established set of goals and work plan prior to the commencement of the trip, it is even more important to realize that conditions will change and adjustments will need to be made in the field.

Proposed Implementations of Lessons Learned

In preparation for subsequent visits to Nakor in the spring of 2005 and 2006, the lessons learned will be implemented, and doubtless new ones will be learned.

A significant effort will be made to improve communication among the group and to clarify the role of each group member within the project. Additionally, training sessions will be undertaken to increase each student's mechanical skills. It is intended to again include non-engineering majors on the trip, because they also provide valuable contributions to the project.

Tools of higher quality, such as pipe wrenches, will be brought from the United States in order to improve the efficiency of construction in Nakor. Efforts will be made with the local contact to purchase higher quality materials in Kenya, without placing the cost beyond the amount that could be reasonably raised by the local people should they need to repair or wish to replicate the system.

Once on site, meetings will be held daily to update project participants on the status of each portion of the project and to organize the next day's efforts. Gatherings will also be held between the travel team and members of the host community in order to explain the project to them and clarify any questions or concerns the local people might have. Additionally, two-way radios will be provided to each group to facilitate communication between groups working at different locations.

Lastly, and perhaps most importantly, a more realistic expectation of what can reasonably be accomplished and a recognition of the need to accommodate change will be adopted before, during, and after the trip.

Conclusions

While the project did not accomplish all of the tasks originally intended, it should still be considered a success. A garden was established during the trip that has since produced foodstuffs with regularity and the windmill pump installed have provided clean drinking water for the people of Nakor. Additionally, members of surrounding villages have traveled to Nakor to observe the success of the project and learn how they can create similar systems in their own villages. Lessons about technical aspects, such as the need for better tools and materials, were learned, but more importantly, the benefit of incorporating a group with diverse interests and talents was realized, and the need for better communication, training, and flexibility was established. These lessons will be applied in order to improve future trips, both to the village of Nakor, and to subsequent projects undertaken by EWB-VU.

Figure 1: The EWB-VU project team with the Mordens, the Matterns, and the translators.

Figure 2: The windmill-powered well near the river.

Figure 3: The installation of the drip-irrigation system

Biographic Information

CARMINE POLITO is the Frederick F. Jenny, Jr. Professor of Emerging Technology at Valparaiso University where he has taught civil engineering for the last four years. He serves as faculty advisor to the Valparaiso University chapter of Engineers Without Borders. He wishes to thank the Mordens, the Matterns, and the people of Nakor for their help, without whom this project would not have been possible.

RACHEL HUSFELD is the student president of the Valparaiso University chapter of Engineers Without Borders. A junior civil engineering major, she is originally from Houston, Texas. While in Nakor, Rachel received a wedding proposal with a bride price of twelve camels, six donkeys and thirty goats. After consultation with her family, she has decided to decline the offer.