AC 2008-1476: USING APPROPRIATE TECHNOLOGY AND SOCIAL ENTREPRENEURSHIP TO HELP TRANSFORM POOR COMMUNITIES

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Introduction

Many approaches to poverty issues are from a top-down perspective using governmental policies and spending to try to make changes. This paper examines a bottom-up approach using technology and social entrepreneurship as tools to make a difference in the economies of developing nations. As local people are equipped with the knowledge and skills of appropriate technology and social entrepreneurship they can improve their lives. By social entrepreneurship we mean the development of companies that have as part of their purpose the improvement of the local society in which they are created. In order to do this they also have to make a product that people want at a price that will allow them to make a profit and stay in business.

Engineers play a critical role in this process. The technological advances of the past century have brought a dramatic improvement in the standard of living for the most fortunate one billion people in the world. However, too little attention has been given to developing technology that can significantly improve the quality of life of the poorest two billion people who struggle just to survive. This technology needs to be simple, cheap, manufactured in country, easily maintained by nationals in rural villages, and culturally acceptable. Basic human needs for clean water, a small source of clean energy (e.g., electricity rather than kerosene lanterns for lighting, for example), and sanitation are seldom met.

With a focus on service, technology can be an instrument of peace, community development, restoration of human dignity, and the alleviation of hunger and suffering. This happens as these endeavors and their practitioners orient their craft toward an end that has meaning as well as economic profit.

We will illustrate our approach by discussing engineering service projects that students in our university have completed. They have implemented projects in East Africa and Central America. We are currently working on other projects in the Pacific Rim. These case studies will be analyzed to show how student engineering service projects can transform lives. The students who participate also have their own lives changed as they gain a new vision on how to practice engineering.

Background to Our International Involvement

Our program of international involvement is a significant step in our goal to make service learning a larger component in our engineering program. This project is also one step in the process of expanding our research work in appropriate technology.

Our students gave up significant amounts of time, effort, and money to serve poor people in another part of the world. This application of appropriate technology in a developing country is very consistent with Baylor University's mission, part of which is:

> *"to educate men and women for worldwide leadership and service."*

These projects are an outgrowth of a student created service organization. This group promotes engineering service projects in other countries. It is loosely patterned after Engineers Without Borders from whom they have learned a great deal. The students who started the group wished it to be separate from Engineers without Borders so that they would not have to deal with the bureaucracy inherent in any larger organization. They also wished to have a service organization that was explicitly faith based, as is Baylor University. The author is a member of Engineers without Borders and this membership has been very helpful.

Engineers are not the only people who are trying this bottom-up approach. Non-engineering examples of such an approach to poverty are described in the excellent book[1] by Shannon Daley-Harris and Jeffrey Keenan.

Criteria for Successful Engineering Service Projects—Preliminary Work

Successful projects do not just happen. If the project is to be successful there are some things that need to be done before the project can be implemented. They are:

1. Have contacts in the country who are interested in having us do the project and who can act as a resource.
2. Know enough details about this project so that the design work can be done during the academic year at our university.
3. Raise enough money to pay for travel to the country and to purchase the needed equipment.
4. Have someone from our university handle logistics on the ground in the other country so that the faculty member and students can concentrate on the engineering project and not get overwhelmed by just surviving in that country.

<u>Local Contacts</u>

This is a critical component for the trip to be successful. For this to occur there may need to be a small exploratory trip occur before the major trip can be organized. For example, six students and three professors from Baylor went to several locations in Kenya in spring 2005. These locations were based upon prior contacts that the professors had with people in the country. While there were some minor engineering projects completed during that trip, its main purpose was to explore future possibilities. Results from this trip were reported at the spring 2006 ASEE regional conference in Baton Rouge[2].

This exploratory trip resulted in two groups of students going to Kenya in 2006. One group installed a wind powered electrical system in the Kibera slums of Nairobi. The other one put in a water purification system at a Deaf School in the western Kenyan town of Oyugis. This school did not have a permanent source of electricity to run the purifier. Therefore, part of the project was to design and install a solar powered electrical system for the school. This was reported on at a 2007 ASEE regional conference in South Padre Island[3].

In January 2007 a professor led a small team of students to Honduras to examine the possibility of installing a small hydroelectric system to a mountainous village. This led to a larger group going in the summer of 2007 to do the actual installation. The author has since received a grant from the National Collegiate Inventors and Innovators Alliance (N.C.I.I.A.) that will allow this to be replicated in other villages.

The author went to Rwanda in January 2008 to examine potential projects. There are several electrical and water projects that could engage Baylor engineering students. This includes helping out the Sonshine School near Ruhengeri, Rwanda, and a medical clinic in Shyira, Rwanda. Good contacts were established at these two places. They are very interested in a team of Baylor engineering students coming to help them in spring 2009.

<u>Design work done ahead of time</u>
Engineering design work takes time, and this needs to be started at least six months before the trip. This will allow a tentative final design to be completed, and all items that cannot be purchased in country obtained. Recognizing the nature of the developing world, students should expect that some things will need to be changed once they get to the project site. To save shipping, and to help the local economy as much as possible, most equipment should be purchased in the country where the work will be done. From a maintenance perspective, it is also important that replacement parts be readily available. This constraint may well change the nature of the design itself.

<u>Raising money for the trip</u>
Engineering service trips are not cheap. For example, the per person cost of the 2006 Kenya trips was about $2,500. In addition to that each group had to raise about $2,000 of equipment money. The faculty and the university need to be ready to help the students raise the funds for the trip. Some student families can pay for the trip, but many are not able to do so.

Cost should be something that goes into the decision making process about which trips to do. While we will continue to do work in East Africa, one of the reasons we have begun to work in Central America is that it is much closer and the costs will be less. The time involvement will also be less. For example, to get to Rwanda, it is an 8.5 hour flight from Atlanta to Brussels and then another 8 hour flight from Brussels to Kigali. On the other hand, it is only a three hour flight from Houston to Tegucigalpa, Honduras.

<u>Logistics</u>
Logistics in a developing country can be quite complex for a group of students and faculty members who have never been there before. For them to be productive there needs to be someone in the country who can handle some of these issues. When the team went to Kenya in

2006, the two engineering teams were part of a much bigger set of service projects organized by our university, involving about 100 people. Two staff people from Baylor went ahead of time and organized hotels and vans with drivers for each group. On the author's recent trip to Rwanda, our host provided us with a car and driver for the week, and also made all of our hotel reservations. Having these details done for us made the trip much more productive. If a student team is trying to do all of these things by themselves, they will be much less productive doing their engineering projects.

Example Projects

Baylor students have completed projects in a variety of different countries. Among there are:

- Three projects in Kenya (one in 2005 and two in 2006).
    - Wind powered electrical system and water purification system.
- One water project in Honduras (two trips in 2007)
- One project in Armenia (2007). This was building a demonstration home using Styrofoam bricks
- One project in the Philippines (2007). This was assisting a small company in the development of products from coconuts.
- Two projects under development in Rwanda for implementation in 2009.
- Small projects in Vietnam and Papua New Guinea.

This paper will illustrate some of the work in Kenya. In spring 2005 three professors and six students went to Kenya. They explored a number of potential projects, and helped out with a few. They installed a rudimentary electrical system at a Deaf School in Oyugis. This contact led to a more complex project in 2006. They helped build a pedestrian bridge with a group called Bridging the Gap-Africa. A photograph of their bridge is shown below. More details about the trip are reported in reference 2.

Figure 1—Building a 135 foot long pedestrian bridge over the Nzoia River in Kenya

Contacts made while working on this bridge project led to the engineering design collaboration described in a later section.

In 2006 a team went to Oyugis, Kenya. They installed a water purification system in a Deaf School that did not have a source of electricity. We installed a second solar panel, a charge controller, and battery to run the purifier. More details are described in reference 3. They also improved the basic lighting system that had been installed the previous year. Along with the engineering team were two other service teams from our university. The Deaf Education team worked with the students and staff at the Deaf School. The medical team provided needed medical services to the school and to nearby villages. The photo below shows the water purification system being installed.

Figure 2—Installing the water purification system

In addition to the water purifier system, the team completed a number of smaller projects. A water catchment system was installed to catch rain off of the roof of their building. Their infrastructure was improved by adding additional supports to the roof of their classroom building. Brick steps were added to their building so they would not have to climb up a pile of rocks to get into the building.

There are many issues we had to deal with in Western Kenya. Western Kenya introduced a number of unpredictable variables into the project and required some creativity and a lot of patience. During the two week trip, ordinary activities in the U.S. quickly became challenges. The team stayed in the Monarch guest house on the outskirts of town. Electricity and running water made these accommodations phenomenal according to local standards. The team slept under white mosquito nets, which took engineering to hang, and only ate "safe" food at the guest house for breakfast and dinner to avoid getting sick. More than discomfort, these conditions gave a panicky sense of remoteness that required a level head. Little things like brushing teeth with bottled water were constant reminders of our foreignness (the only non-bottled water we drank was shared from the first glass purified at the deaf school).

Communication and mobility also became factors in our work. Kenya is more difficult to navigate in than the U.S. Six hours of the drive from Nairobi to Oyugis passed by giraffes and acacia trees over smooth two-lane roads. The other two hours moved through overcrowded, impoverished cities and beside roads too pockmarked to drive on. Driving in Western Kenya could be beautiful but cumbersome. The nearest major city was 3 hours away. The team communicated by cell phone with the Engineering team in Nairobi. On one occasion, one of our team members called the electrical engineering professor in Nairobi for design advice. They did not have access to the internet.

Western Kenya hosts all sorts of diseases unknown in our home state. These became a major factor the last three days of our stay in Oyugis. On Wednesday night of the second week, several members of the deaf education team got sick. By the next evening, only 14 people of the thirty people staying at the guest house were healthy. 80% of the team was too sick to work on Friday of the second week. Fortunately, most of the projects were finished by Thursday afternoon and the remaining members of our team had enough perseverance to finish.

Procuring the materials for most of the projects was also a challenge. Despite the suitcase of tools the team brought to Oyugis, we needed additional tools for the water collection system and the steps. To complete the project the team made several trips to the Western Kenyan home improvement stores. Oyugis' small hardware store was a counter in the open-air market wedged between a mattress/clothing store and an ATM with an armed guard. There we got tin gutters and heavy linked chain. They drove thirty kilometers to Kisii for the Kenyan Wal-Mart, Nakumat. At Nakumat they bought an 80 watt solar panel. Also in Kisii, the team bought pipe and an elbow for the collection system at a building supply store with a caged in cashier and a basement full of plumbing pipes.

Engineering Service Projects—Significance

Projects such as the one in Western Kenya are significant for the local Africans and significant for our students.

<u>Significance for the African students</u>

The most important result for the Deaf School students is improvement in their health. Most of them have worms because of their only source of water was contaminated. This hurts their health as the worms absorb what little nutrients they are eating. Treating for worms could have been done earlier, but they would only get them back by drinking more dirty water. As part of this project, the medical team treated the students for worms. With a clean source of water, they have a much better chance of avoiding getting worms in the future, which should significantly improve their health. See Figure 3 below of a deaf student drinking clean water for the first time in his life.

Figure 3—A deaf student drinking clean water for the first time

Significance for our students

This project was significant for our students who participated. The following comments were made by students who were on the trip:

- Human suffering is very ugly. I cannot end it or even dent it. But I cling to the hope that there is something greater than hunger and AIDS and my ability to save people.
- The opportunity to use our schooling and problem-solving skills in engineering first-hand is an incredible medium for learning new applications of science and technology as well as for retaining what we've learned. Putting effort into understanding problems and their solutions and then personally seeing the end result has an incredible compounding effect. Experiences stick with you more than facts, but when facts are coupled with experiences it allows you to better understand both the principles and their applications.
- The implementation of these projects both blessed the children and staff at the Kenya Christian School for the Deaf and enhanced our knowledge of practical engineering in poorer countries. This experience in service was a great complement to our education.

Engineering Design Collaboration

The contacts made in Kenya in 2005 when our students assisted in the construction of a pedestrian bridge has led to a further collaboration. This group has been approached about building a 420 foot long bridge (345 feet between towers) to go over the Galana River in southeastern Kenya. This is much longer than they have ever done before, and they contacted our university to find out if we can give them some engineering guidance. We have had a group of four students and two professors work on this project for the past year. Details of this preliminary work are reported in another location[4]. This remote location has led to difficulties in obtaining the data needed to make the final design. While the river is not always deep, there are frequently crocodiles in it, and someone has recently died while trying to cross the river. The photo below shows some people measuring the river's dimensions. Note that they are also carrying weapons to protect themselves.

Figure 4—Making measurements on the Galana River in Kenya

The complexity of the project has been a challenge for the students. They have learned to search out additional information. They have obtained Google Earth photos of the bridge site to help in understanding the design issues they face. They have obtained wind data from nearby locations to aid in designing how much wind resistance needs to be built into the bridge. We hope to have some of the students and faculty go to Kenya for the actual building of the bridge in late 2008. However, the current political instability in Kenya (as of January 2008) may cause the construction to be delayed somewhat.

Recommendations for future projects

We have several different recommendations. These recommendations relate to the trip itself:

- The logistics were arranged very well by staff members at our university. We recommend that they continue to do this. This allowed the engineering faculty and students the freedom to concentrate on working on their projects.

- We recommend that each trip include an exploratory component so that future projects can be planned without the expense of separate exploratory trips.
- Given the health issues we faced, we recommend that some health care personnel come with any engineering group that is going to a rural site in East Africa. The potential for serious illness is too high to risk not having someone on site to be able to help us.

There are some other issues that relate to making service learning a more important part of the Electrical and Mechanical Engineering programs at our university. One example would be to make the projects technically more challenging, but also allow the students to get three semester hours of technical elective credit for working on this project. By giving academic credit for such activities, the students will have a greater commitment to the project, as well as have more time to work on it during the semester just before deployment. This approach is being used in spring 2008 with the two students working on this project receiving three semester hours of independent study academic credit. Progress on the project is indeed being made faster as a result.

Manner in Which Projects can Benefit Poor People

Most of the projects we have done have had a direct impact on people by providing things they can immediately use, such as electricity and clean water. As people are healthier (because of clean water) they can do many other things to improve their own lives that could not be done when they had poorer health.

Another part of how these projects can be used to help poor people is by helping them start small businesses so that they can continue to improve their economic condition. For example, in 2007 a group of students and a professor built a Styrofoam house in Armenia. The project goal was to help get businesses started there which can continue to do this work. In 2007 two students went to a rural area in the Philippines to observe and help a small company make products from coconuts. Also in 2007 we helped put in a micro-hydroelectric system in a remote mountain village in Honduras. A photograph of this installation is shown below.

Figure 5—Installing a micro-hydroelectric generation system in Honduras

This provides electricity for a local village. By charging a nominal fee, the villagers can support the costs of maintenance and have some extra money to pay for additional village needs.

Baylor University has recently received a grant from the National Collegiate Inventors and Innovators Alliance (N.C.I.I.A.) to expand this process to other villages by creating a way to franchise this approach. This will allow even more villages to have electricity and profit from the generation system. The initial funding for this project is coming from N.C.I.I.A. Profits from the first franchise can be used to help fund future franchises. N.C.I.I.A. has provided Baylor with contacts in the micro-finance world so that we can pursue additional funding to accelerate the rate at which new franchises are created.

An additional way where we could expand this process is to work with microfinance organizations in developing countries to help support villagers who wish to expand upon our work. An example of this was seen by the author in January 2008 when he visited the Urwego Opportunity Microfinance Bank in Kigali, Rwanda, which is shown below. This bank makes loans to groups of poor people in rural villages so that they can start/expand their own small businesses. A typical group loan might be $1,000, which can support 20 to 40 small businesses. This means that many individuals get loans on the order of $25 to $50, which can be large enough to make a big difference in their lives.

Figure 6—Microfinance bank in Kigali, Rwanda

Cooperating with other Groups

Partnering with local organizations can produce more impact as they can continue the work long after the team has left. It is important to train the local people how to maintain whatever system has been installed. It is also important for the local people to have a sense of ownership of what has been built/installed. One example of this is Bridging the Gap-Africa with whom we have cooperated on two projects. Before they agree to build a bridge they require that the bridge be requested by the local community. They train local people in how to maintain the bridge after it is in use.

An example how this can be done was seen by the author on his trip to Rwanda in early January 2008. He visited with a non-profit group called Living Water, which drills water wells for needy villages. Before they are willing to drill the well, the local village must invest some money in the well. This is frequently not enough to pay for the actual drilling, but is required to give the village a sense of ownership. The village then needs to agree to maintain the well and to charge a token fee for the water to pay for the maintenance.

An example of a water well being dug is shown in the photo below. This photograph shows the drilling just after they have hit water about 40 meters below the ground surface. Note that while the equipment was purchased from money donated from the United States, the entire drilling operation is done by Africans.

Figure 7—Drilling a water well in Kicuriko village, Rwanda.

An example of a village water well is shown in the photograph below. Young people are pumping the water for use by the villagers.

Figure 8—Water well in use by a local village near Kigali, Rwanda.

The example of the Living Water organization can serve as a model for future engineering service projects. It shows the importance of involving the local people from the very beginning.

In 2009 we would like to work with the Sonshine School near Ruhengeri, Rwanda. They are an excellent school that was originally created largely to teach children who were orphaned in the 1994 genocide. They now teach many other children as well. They have needs for purifying their water. Currently they boil it in wood charcoal based stoves, which takes a lot of work and pollutes the kitchen area. They also have problems with electricity. Their source is not stable and very expensive. They are trying to use computer labs and need a better source of cheap electricity that is also stable. A photograph of part of their school is shown below.

Figure 9—Sonshine School near Ruhengeri, Rwanda

Conclusion

It is possible for college students to have a significant impact upon poor people in the developing world by using a bottom-up approach. As more engineering students work in this way, many communities can be transformed.

References

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