Engineers Without Borders-Montana State University: A Case Study in Student-Directed Engagement in Community Service

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Abstract

Engineers Without Borders at Montana State University (EWB@MSU) is an organization that has been successful in generating increased student engagement through service learning and is unique in the degree to which the organization has been built and directed by student volunteers. For the last decade, students have been self-motivated to manage an organization that collaborates with primary schools in the Khwisero district of Western Kenya to develop water and sanitation solutions. The continued success of the organization requires students to overcome the difficulty of year-to-year continuity, develop skills to undertake complex problems, and work in an unfamiliar culture to implement projects. To address these challenges, students engage faculty advisors, professionals (both in the US and Kenya), their peers, and Kenyan beneficiaries to generate solutions collectively. While in the United States, students gain the skills necessary to undertake the activities of an international aid organization while simultaneously developing the next generation of student volunteers. While in Kenya, students continue to develop skills to overcome difficulties associated with international development where strong interpersonal and cross-cultural communication, project management, and an awareness of power differentials are necessary implement projects successfully. We propose that the motivation required for continuing the work of EWB@MSU is a result of the level of autonomy the students have, in conjunction with the mentors and advisors who champion and support project-based learning. This case study explores the lessons learned in the development of a self-motivated student organization conducting a long-term international service-learning project.

Introduction

Engineers Without Borders at Montana State University (EWB@MSU) is a student chapter of Engineers Without Borders-USA (EWB-USA). EWB-USA is committed to working with student and professional chapters to address the Sustainable Development Goals as defined by the United Nations 2030 Agenda[1], one of which is clean water and sanitation. Throughout its history, the student members of EWB@MSU have sought to make improvements to the way they design and implement projects and the way in which they interact with the community. These improvements and initiatives are largely student-led and have varying degrees of success but have great potential for enriching learning experiences as will be evident in the following case study. The students and mentors involved in this process volunteer a significant number of hours to EWB@MSU meetings and fundraisers. This affords students an opportunity to develop their own solutions to diverse, multi-cultural problems with their peers and mentors. This inductive style of learning inspires students to engage in the process[2]. The project-based and problem-based learning model provides an opportunity for increased engagement not only in students' respective studies, but in developing the strong communication, leadership and life-long learning skills that are required for success both in their careers and EWB@MSU projects. Inductive methods promote a deeper approach to learning. They also promote

intellectual development and help students gain the critical thinking and self-motivated learning that will help them thrive[3].

EWB@MSU is currently comprised of approximately 50-60 student members from engineering and non-engineering disciplines. Since its inception in 2004, EWB@MSU has worked to develop a long-term development relationship with the Khwisero community in Western Kenya to provide clean water and sanitation at its' 63 public primary schools. Dedication to water and sanitation development for Khwisero has created the foundation for self-sustaining student engagement. EWB@MSU student volunteers have shouldered the responsibility for developing a robust and growing undergraduate organization involved in international development work. The continued success of the organization requires students to overcome the difficulty of year-to-year continuity by engaging mentors (both in the US and Kenya), their peers, and Kenyan beneficiaries. The success of the organization relies on individuals to work together to develop the technical and communication skills required to undertake complex technical and social problems while working in an unfamiliar culture to implement and sustain projects. In addition to these challenges, EWB@MSU has tended toward a collaborative and consensus-building style of decision making which often results in frustrating but significant learning opportunities for both students and mentors. This paper presents a case-study for an EWB@MSU water development project that began in 2013 for the Munjiti Primary school. This project exemplifies the learning opportunities that result from student-led management and decision making. A brief history of the EWB@MSU chapter's inception and development will be presented to give some context for the case-study.

In 2003, Ronald Omyonga initiated the process that would eventually bring EWB@MSU to Khwisero by writing a proposal for water and sanitation development aid to EWB-USA. Omyonga is a well-respected graduate of one of the primary schools in Khwisero that EWB@MSU would later serve and is currently an architect living in Nairobi, Kenya. He wished to increase the standard of living as well as opportunities for social and economic mobility for the residents of Khwisero. Concurrently, a group of undergraduate engineering students at MSU established a chapter of EWB@MSU and responded to Omyonga's proposal for partnership in Khwisero through EWB-USA. EWB@MSU's interest in working with multiple schools resulted in a long-term project where prioritization of building sustainable relationships and designs within the Khwisero community is critical. The Khwisero sub-district is home to approximately 110,000 people who live primarily by subsistence agriculture but is also home to politicians, government employees, teachers, small business owners, and professionals[4]. Many individuals speak three languages, their "mother tongue" or tribal language, Kiswahili (also known as Swahili), and British influenced English. The region is organized around clans, sub-clans, and extended families that are centered at primary schools and churches. Access to basic infrastructure in Khwisero is changing rapidly. More and more public institutions and market centers have electricity, water, and sanitation facilities as a result of both non-government (NGO) and government investment. In recent years, the national government has decentralized power from large provinces to smaller counties and access to technology and global influences has increased[4].

In 2004, two student members of EWB@MSU made a trip to Khwisero to meet Omyonga and other members of the community as well as to collect information on the sanitation and water

conditions in the district. The first borehole was drilled in 2006 at the school Omyonga attended as a child. A second borehole was drilled in 2007 and by the end of 2008 three more borehole projects had been implemented. Student members of EWB@MSU were working with schools less as leaders and more as learners, as the schools arranged for local solutions to the maintenance issues presented by the students. This resulted in long-term success of the wells at those three schools but came with three different management structures. Locally specific management structures were found to be effective, but increased the importance of the social work accompanying the projects. The importance of the social component increased the diversity of the organization, which then improved the quality and resiliency of the organization but with increased complexity[5]. With increased complexity in the organization competing objectives began to develop. On one hand, the original mission of providing water and sanitation services to the 56 primary schools in Khwisero mandated building a well-functioning development organization that could manage and design appropriate engineering solutions. On the other hand, as a primarily volunteer, student-led organization with high turn-over and abundant amateurism, a mechanism for investing in and building student leaders was necessary. These objectives are inter-dependent and oftentimes contradictory, creating a complex interplay in allocating resources within the chapter. During this period, in addition to struggling with competing objectives and continuing to design and implement projects, the chapter established a Kenyan board to provide advice, legitimacy within the community, and a mechanism to rank schools in terms of need[5].

Between 2012 and 2013 it became apparent that the functionality of the projects that EWB@MSU had undertaken still wasn't as high as was desired and a qualitative positive correlation between the quality and quantity of time working with the school communities to achieve successful projects was evident. Several projects continued to encounter operation and/or maintenance issues and many schools did not have the financial resources or management skills to address the problems. In response, a student-designed initiative was implemented to increase the amount of assessment time spent at each school. The assessment process outlined by EWB@USA was built upon, to include a one-year assessment/capacity building period after the Khwisero Board selected the school; this was followed by a year of project implementation, and subsequently with multiple years of project follow-up obtaining both quantitative and qualitative metrics of project success. Members of each travel team now dedicate time at completed projects with the intent of identifying technical and social problems to improve future design and implementation as well as to provide to support to the 38 projects implemented at 28 primary schools in Khwisero.

Munjiti Primary Part I – Drilling the Well

In August of 2013 the Munjiti Primary school was selected by the Khwisero Board to be one of two schools to receive a water project in the following implementation season (Summer 2014). At that time, the administrators at the primary school were notified that they were selected to receive a water project. Munjiti Primary school is located in the north-east corner of the district and serves approximately 600 students from pre-school to 8th grade. This school had two previous water projects installed by two different NGO's. They have a dry, hand dug well in the south-east corner of the property and two concrete cisterns near the classroom buildings for rainwater catchment that are in disrepair. Because of a transition to new operating procedures,

and in an effort to work through the Kenyan selection board, site assessment was performed by partners in country and a geotechnical survey was contracted and obtained prior to drilling. This school was selected for implementation and the well was drilled the following summer, on EWB@MSU student member's first trip to this school.

In the two semesters following selection, student volunteers from EWB@MSU prepared designs and paperwork for the Munjiti project to be approved by EWB-USA. The standard well design used previously by EWB@MSU was also used for this school and was approved by EWB-USA. Well projects were seen as routine by EWB@MSU students and much of the paperwork and design documents were copied from previous projects. The travel team dedicated to the Munjiti project consisted of a student project manager, three additional students, and two professional mentors. Due to mentor scheduling issues, the professional mentor for this team changed over half way through the trip. This team was tasked with hiring a contractor, coordinating with and training the project management committee at the school, and overseeing the drilling and construction of the borehole. In addition, some members of this team had personal research projects that they were completing and other related project tasks within the district of an administrative nature.

The contractor selected to drill the well was one that EWB@MSU had worked with on several other occasions. The contractor selection process and mobilization went as smoothly as things go in rural Kenya and by the time the second mentor for the team showed up (approximately 3.5 weeks into the 5 week trip) the drillers were well into the drilling process. The school and surrounding community were very excited and lined the road next to the school in anticipation of the completed well. At this point, drilling had reached 170 m and the drillers recommended quickly air testing the well to determine an approximate water yield which they suspected might not be adequate. As this was taking place, the EWB@MSU travel team asked the driller to provide them with a copy of the hydrogeological report. Shortly thereafter, the driller informed the team that the water supply from this borehole was both deep and had a very low yield. It was so deep that none of the hand pumps originally selected for the design were sufficient. An option presented by the driller was for an electric pump that might pull water continuously and fill an above ground storage tank. However, it was unlikely that the yield was such that this continuous pumping would provide sufficient water for the school. Concurrently, the team reviewed the hydrogeological report which suggested the results evident by the drilling, insufficient water – very deep. The hydrogeological report was prepared by a Kenyan geologist prior to borehole permitting. The hydrogeological investigation included geophysical measurements of resistivity in two locations on the site and an interpretation of these results. When the driller was questioned about the hydrogeological survey he concurred with the team's interpretation but stated that he was doing what was dictated by the contract which told him to drill to 170m and to attempt to develop the well. It was felt that the water quantity, spotty electricity, and higher maintenance cost for a more complex system did not warrant the financial investment in an electric pump. The EWB@MSU student project manager and the professional mentor, in consultation with EWB@MSU leadership in the US decided to abandon and backfill the borehole.

This left the EWB@MSU team in Kenya to explain to the school project management committee the decisions being made on their behalf and to discuss possible plans for moving forward. A

meeting was held in which this decision was explained and the school was told that EWB@MSU would try to find another water development solution for the school. The EWB@MSU team explained that they couldn't guarantee a project for them as the funding was not secure and the EWB@MSU chapter needed to come to a consensus to continue with the project and have a new design approved by EWB-USA. With that, the team quickly switched to assessment mode for the final week on site and worked with critical stakeholders in the school community to continue to develop a feasible plan. It was tentatively decided by the Munjiti Project Management committee (PMC) and the travel team that a rainwater catchment system (RWCS) could work for the school. EWB@MSU had designed and implemented a similar system at a nearby school. In the time that was left for the travel team they did a thorough site plan including many photos and measurements of the existing roof and gutters. The students also tried to make an improved estimate for water use at Munjiti and they visited the neighboring school with a rainwater catchment system to learn in more detail how their system was functioning. Upon departure from this school the Munjiti community was confident they would eventually have a functioning water supply system, more confident than the travel team who still had to get approval from the EWB@MSU chapter to continue with the project.

Munjiti Primary Part II – Providing Water

Back in the United States, the job of summer travelers shifted to working with the general organization to make a case to continue the working relationship with Munjiti, providing inspiration and education sufficient for the project to continue. The student managerial board and project management groups came to consensus on funding additional works at Munjiti and a committee was formed to work on the design of the rainwater catchment system that included the second professional mentor from the Munjiti 2014 travel team. Significant changes were made to the previous rainwater catchment system design. Most notably, the water treatment system (sand filtration) was moved from below ground and designed as an on-demand system. A change in professional mentors was made during the design phase when it was determined which professional mentor would be traveling with this team, the new mentor for the RWCS group being the EWB@MSU faculty advisor. Concurrently students worked to fundraise for implementation, discussing with the Bozeman community, the failure/lessons learned and anticipated path forward. With the design and funding complete the design was submitted to and approved by EWB-USA for implementation during the 2015 travel season.

The same contractor that had drilled the well at Munjiti the previous summer was hired to construct the rainwater catchment system. Some on-site design changes were made and construction was completed near the end of the time for the travel team associated with the implementation of the RWCS. One seemingly small task remained for a complete system, the sand needed to be graded and cleaned for the sand filter. A small set of laboratory screens was brought from the US for this purpose and the EWB@MSU students and contractor provided laborers spend the rest of the summer sifting sand all day, every day. As EWB@MSU teams came and went this task was handed off from team to team either to sift sand, or make sure that the contractor was sifting sand. This resulted in a misunderstanding between students and the contractor. After the sand sifting project had been handed to a new team for the second time, the team currently tasked with achieving completion of the sand sifting project believed that the contractor was being paid to complete this task. This led the students to believe that they could

increase the pressure on the contractor who eventually told the students that they were completing this task for free and it was not included in their contract. Two days prior to the departure of EWB@MSU from Kenya (the last travel team for the summer), EWB@MSU signed off on a complete project at Munjiti Primary School.

Lessons Learned

The most obvious failure associated with the Munjiti borehole project was that a dry well was drilled and that the time and expense associated may have been avoidable. This was primarily the result of the process of preparation and review of the design documentation being seen as mundane and repetitive. The culture in EWB@MSU at the time placed a high priority on being socially responsible in the community and did not prioritize the technical aspects of assessment and design for well implementation. In this case, the hydrogeological report was not reviewed by either students or mentors of EWB@MSU as part of the assessment process. Additionally, the contractor was not motivated to point out any obvious flaws in the construction plan. The hydrogeological report did indicate that water quantities would likely be low, but no red flag was observed, as the report indicated there would be some amount of water. The process of assessing the site for well implementation was considered cumbersome and boilerplate, and the perceived value of the design paperwork preparation and review was low. Students learned from this failure that there is value in the technical aspects of site assessment and design for a borehole project. Travelling mentors learned that they need to take a greater role in the design and assessment process, particularly if they are to be the engineer of record.

Another less obvious failure in this project, was that the Munjiti community was not engaged in the in the design and decision making process. They were not consulted when a decision was made to abandon the borehole. They were not engaged in a truly collaborative way to come up with an alternative water project. And they were not engaged during the design decisions made during development of the rainwater catchment system. This does not result in a truly sustainable development project. For example, a decision was made in the US to design an on-demand sand filter water treatment system for the rainwater catchment system but members of the Munjiti community were not consulted as to whether this would be a viable option. These kind of decisions can result in designs that do not serve the community. This lesson was learned by mentors and some students but the importance of engaging the community in technical design is not widely appreciated.

Finally, a significant lesson learned in both travel seasons was the importance of continuity. This is also a lesson learned in both summers by mentors and students. During the first travel season there was a discontinuity in mentors, the first mentor was the one involved in pre-implementation paperwork and had the experience of being involved in the initial relationship development with the community. It would have been ideal if this mentor had been able to stay through the entire trip. At the very least, it would have been helpful for the two mentors to be in communication with each other during the transition. The second mentor arrived as drilling was being completed without having met the students or having been involved in the pre-implementation paperwork. For both mentors involved in the Summer of 2014, it was their first trip to Khwisero. In the second season, there was certainly a design/construction error in the way the sand was prepared for the filter. However, it was really the fact that the

construction continued through the entire summer that created potential problems in continuity. As each team handed off the project to the next it was as if a summer-long game of telephone was being played. By the end of the summer, as the final travel team attempted to sign off on the project with the contractor, it was unclear who was responsible for the sand sifting and cleaning, how much sand there needed to be, and how to advise the school as to the operation and maintenance of the filter. This lesson did not result a major failure but it was clear to both the students and mentor involved that maintaining continuity and communication throughout a summer travel season is difficult and important.

Conclusion

In the case study presented, students and members of the community were resilient, and worked together to build from a failure. A potential solution, the rainwater catchment system, was proposed and both the involved community members and traveling team had to motivate their extended communities to fund and continue work at the school. The primary school community hosts the traveling teams while they are in country which requires significant organization and fundraising. Munjiti had agreed to host the travel team for a second travel season as a result of the failed borehole. The community and the students shared the responsibility of recovering from the failure.

At MSU, several actions occurred as a result of the lessons learned that strengthened the organization: 1) the dry well was presented to the broader organization as a challenge to overcome and, 2) the dry well raised questions about the assessment process (in particular reviewing the hydrogeological surveys), and the borehole contracting and drilling process. Transitioning from a failure to a solution required the travelers and leadership to embrace the problem, educate their peers, and inspire funders. The extent of the education and work required was large, not only were designs for a new build project required, but an incredible transfer of community and working knowledge was necessary so that a new group of students could pick up where the last left off. Investigating how the failed borehole was approved exposed multiple failures in the organization, most which could be tracked to individuals and organizational culture. The challenge for the group was to not blame, but to collaborate with the individuals now empowered by their experience of failure to engage their peers to work to alter the culture and operating procedures of the organization.

The success of EWB@MSU is two-fold. First, potable water and sanitation projects are developed with primary school communities in Western Kenya. The second and most notable success, is that students are able to take the lead on projects, realizing that the solutions are bigger than themselves and require diverse teams. The students find a level of engagement in the project-based learning that they don’t often find in their traditional studies. However, as a result of the challenges and educational model discussed in this case study the student members of EWB@MSU cyclically relearn certain lessons. The challenge for the mentors and advisors is in defining which lessons are important for each group of students to learn and relearn for the organizations success. Mentors and advisors must also in find a balance between an entirely democratic student-led model and an authoritative mentor-led model where failure is minimized. An overly democratic model may result in unqualified students making poor and potentially unsafe project/design decisions, while an authoritative model may diminish the motivation individuals have for their projects and thus limit engagement in their extracurricular education.

While this case study included a significant level of perceived failure (tens of thousands of dollars were spent to drill a dry borehole). That failure provided an opportunity for multiple generations of students to critically assess past actions and develop a better system for the next generation of students. The opportunity to provide this type of learning has been embraced (with varying degrees of enthusiasm) by the advisors and mentors for this group, the university, financial supporters, and Kenyans. With thoughtful selection of the primary parameters that are being optimized, this organization has been able to maintain a level of consistency over time. As the organization continues to develop, it is required that mentors and advisors find ways to maintain and improve while facilitating, alongside student leaders, the cyclic learning style of the student-led organization.

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