AC 2011-750: "IT’S GONNA BE A LONG TRIP"- A STUDENT’S EXPERIENCE WITH ENGINEERING ABROAD.

Tiago R Forin, Purdue University, West Lafayette

Tiago Forin is currently a third year student in the School of Engineering Education at Purdue University. He received his Bachelors degree in Civil Engineering from Florida State University in '06 and his Masters degree in Environmental Engineering from Purdue University in '08. While in the School of Engineering Education, he works as a Graduate Research Assistant in the X-Roads Research Group and has an interest in cross-disciplinary practice and engineering identity development.
“It’s gonna be a long trip…but we’re gonna get it done.”

A student’s experience with engineering abroad.

Abstract

This paper uses a narrative to take the reader on a reflective journey of a student’s, the author’s, perspective of a water filtration project that was developed at Purdue and implemented in Eldoret, Kenya. While involved in this global engineering project, I was placed in scenarios that were different from traditional classroom experiences, and my classmates and I had to overcome various obstacles. Engaging these obstacles provoked thoughts about the various learning experiences presented to me. How will I interact with classmates that have different disciplinary training? How will the students be brought up to speed on the problem while having an opportunity to design a proper solution? Once overseas, will the trip go according to plan or will we have to overcome further hurdles? The intent of this paper is to describe the various learning experiences of one particular student while involved in a global engineering project. By keeping a photo journal, I was able to capture significant learning moments in the experience that my project leader might not have anticipated. For example, while our goal was to build a filter to provide potable water, I discovered that while the filter provided clean water, more importantly it created extra time for the locals to do other crucial things. By shedding light on my reflections, this paper illustrates teaching opportunities that can be used to help students who wish to have a better understanding of global engineering.

Introduction

Engineering educators have identified the value of problem-based learning and community service in engineering curricula. Problem-based learning allows students to implement their technical skills in a setting similar to what they would encounter in their professional field. Service projects also help enrich student experiences by fostering social consciousness and by giving students the opportunity to see their work being used by disadvantaged people. According to the National Society of Professional Engineers, engineers are called to maintain the health and welfare of those affected by their work and to improve the lives of people by designing solutions to problems. Being stewards to the populace means that engineers are trusted to do what is best for a community. Service projects of this kind can provide a marvelous opportunity for students to prove to themselves that they belong in the professional community. With this personal account of one such project, it is my hope that this narrative will aid engineering educators to take note of the challenges and rewards students can face during an international service project. This narrative may also serve as an example of how students can reflect on their learning through such projects.

In the Spring semester of 2010 I participated in a water treatment project in Kenya. My attraction to this opportunity was due to my experiences as an undergraduate civil engineering student and
my experiences as an immigrant from the developing world. I was a student at Florida State University from 2002-2006 and while I was taking classes in civil engineering; I also took my liberal arts courses seriously. These classes allowed me to better understand non-western cultures and it helped me appreciate the role of aesthetics in engineering design and its impact on society. In my last two years, I became involved with the student chapter of the American Society of Civil Engineers. For the first time, I was able to actually apply what I learned in class while developing a rapid sand filter for a design competition. The experience was rewarding and I began to feel more aligned to civil engineering as a profession. After graduating from FSU in 2006, I enrolled as a graduate student at Purdue University. While completing a master’s program in environmental engineering, I was inspired to look into engineering education.

It was within my second year of doctoral work in engineering education, that I received a notice about the Global Engineering Program (GEP) at Purdue. The GEP offers a special type of study abroad experience to students. Study abroad experiences provide students with opportunities to take part in academic coursework while being immersed in a different culture. One common study abroad program involves students enrolling in a course overseas that is taught by a professor from the students’ home institution. In this scenario, students are given a chance to experience a new culture while still being around fellow students and earning academic credit.

The GEP however, allows students to design an engineering solution to a problem in a developing region while facilitating global learning and engagement with a strong emphasis on service. After developing a solution to a problem faced by a community, students travel to the region for a brief time to build and implement the design. This program was looking for students to take part in various engineering projects in developing regions of the world. I was drawn to this opportunity because I wanted to get involved with an engineering project that would have some impact on people. I applied for and was accepted to a water quality project in Kenya. The problems facing the region of Kenya in question were microorganisms and fluoride concentrations. Microorganisms can cause diarrhea which severely dehydrates the infected person and further impairs the health of those with weaker immune systems while excess fluoride can cause bone damage. Within the scope of the course, the students and the faculty leader decided to address one particular kind of water quality issue, namely the removal of microorganisms. To handle this problem properly, we engaged in a review of relevant literature as well as engaging with an engineering team from Aqua Clara International, who have firsthand experience with water quality issues in that region of Kenya. With this information, we were able to create scaled down models of the actual filter we wished to build and we tested and monitored the filters and the water quality they were producing. The project would be concluded with a trip to the site in Eldoret, Kenya to implement our design. This personal account is meant to give educators an opportunity to see how such a project develops from the perspective of a student. By sharing this account with students, educators who are engaged in similar projects can engage in discussions concerning what to expect from these projects and how to react when the project doesn’t go according to plan.
Beginning the Project

As mentioned in the introduction, the students for this project had to submit an application. I was asked for my transcript as proof of my technical grounding in water quality management. Applicants were also asked to write an essay explaining their motivations for joining the project and what they would contribute to the team. I explained that I wanted to give back to the global community and that I wanted to get back in touch with my technical skills in environmental engineering. As far as nontechnical skills were concerned, I made clear that I was accustomed to travel in a developing nation and that I wanted to use my educational background in particular to address how end users of the filter design can properly be educated in its use and benefits.

Within a month, I was informed that I was selected for the project. Starting in January, we had our first class meeting. Myself included, there were thirteen students in the class. I was the only graduate student but the majority of the class included senior level students from the School of Agricultural and Biological Engineering (ABE) at Purdue. These seniors were using the project as a capstone-design project, a graduation requirement. Two students were from the School of Chemical Engineering and another student was from the School of Pharmacy. These three students and I were the only students from immigrant or minority backgrounds within the class. The gender breakdown for the team was nine male and four female students. Common characteristics that linked our class were that we were deemed proficient enough in chemistry and experimental procedures to tackle the project and there was a genuine desire to help address the drinking water problems.

There were several faculty and administrative members of leaders for our team: the administrative staff of the GEP that oversaw travel arrangements and overall project progress, a faculty overseer for the senior ABE students as a requirement of their capstone design, a small staff of people with field experience from Aqua Clara International, and our project instructor. The project instructor was the faculty member with whom we spent the greatest amount of time. His job was to make sure the students understood the technical aspects of the project and to provide us with the means to successfully test our prototypes. He was the person that the students went to regarding technical issues with our experiments. The project instructor also recognized the added effects of non-technical problems and as such he organized a meeting with a faculty member from our Kenyan partners from Moi University to lecture us about east African culture. He also organized a meeting with our sponsor, Aqua Clara International, in order to introduce us to the field work required for implementing the filter in Kenya. The team at Aqua Clara was small, a husband and wife team, but they provided us with perspective on the people of the region, why such work was important, and what the physical requirements to build a filter on site were. This small field team also went ahead of us to Kenya to provision materials that we would need for designing our filter. I personally only met the faculty overseer for the capstone students once. I cannot comment about his contribution other than to say that he had defined reporting deadlines for the capstone students. The administrative staff from the GEP gave us information
regarding travel, created the itinerary, and provided us with paperwork to secure the necessary travel documents for our trip.

Class Structure and Experience

The class structure was not very different from what one would encounter in a normal engineering class. We had a regular meeting time in the morning for an hour every Monday, Wednesday, and Friday. The first challenge we had to overcome was making sure that all students had the necessary technical knowledge regarding water disinfection, water quality standards, and experimental procedures for collecting microbe samples from water. This was achieved within our first month of the course by reading journal papers detailing slow sand filtration and listening to lectures regarding the management of water quality. We were introduced to our lab space and were lectured as to proper use of the instruments. Within this first month, we had our first meeting with Aqua Clara. There we were told about the dangers of drinking nonpotable water and how people in developing regions are affected by them. It was a jarring experience to see how serious this problem was for those living in such conditions. We were later introduced to the typical filter that Aqua Clara provides in developing regions and how the users in those regions assembled these filters (Figure 1).

![Figure 1](image1.jpg)

**Figure 1.** Practicing how to construct biosand filters for field implementation at Aqua Clara International. Photography by Ernest Blatchley. Reprinted with permission.
The team from Aqua Clara was very curious to know the experimental results of their filter designs and gave us critical pointers on how to properly design their filters. Once we understood the technical design of the filter, we were then ready to build prototypes in our lab (Figure 2). We used water samples from the Wabash River with the hopes that the water would be analogous to the water found in the Great Rift Valley (Figure 3).

Figure 2. The six prototype biosand filters that were used to understand filter behavior. Photography by Ernest Blatchley. Reprinted with permission.
The water of the Great Rift Valley and the ecology of that region posed a problem for the project. Through reading appropriate literature, we knew that the people of the Great Rift Valley suffered problems relating cryptosporidium, *L. Giardia*, and high fluorine concentrations in their drinking water. We were also aware, through our contacts in Aqua Clara, that those most in need of better water treatment lived subsistence agrarian lifestyles and were simply not aware of the problems that exist within their water supply. As a class, we decided to break our problem into three goals:

1. Lowering the concentration of microorganisms.
2. Lowering the concentration of fluorine.
3. Raising awareness of water quality and health.

The results of our laboratory work would be reported back to Aqua Clara to help them understand the effectiveness of their own approach. Aqua Clara was helpful in identifying some locations for us to focus on, a well in a developing neighborhood and the water supply of a local school for girls. Due to political implications and safety concerns in the first location, the class decided on the second site (Figure 4). The school was in a prime location, being close to the Kesses Reservoir, and it was also an opportunity to improve an existing system.
Having decided what the goals of the project were and which site was to be developed, the class was split into three teams. These teams were intended to spearhead a single goal. I chose the third team due to my interests in education. Despite the specialization of the class teams, the entire group was responsible for prototype experiments. This work was done outside of our normal meeting hours and it continued to the end of the semester. The lab work was done in groups of two. It was during this time that I had an opportunity to personally engage students from this class. Since I was outside of their normal schedule of courses, I asked people about their experiences at school, what their thoughts were about the project and their lives in general. I found that this opportunity to get to know my fellow students was important in establishing trust in our abilities as engineers and to make our groups more cohesive.

While communication between students was increasing, problems with administrative communication became apparent. There were multiple times that we had to alter our meeting agendas to accommodate the goals for the capstone students. When we were trying to gather information about the implementation site, there was an issue with the Kenyans being six hours ahead of us (hence our early morning meeting periods). We had a couple of conferences calls with the class which gave us limited information regarding the site. Understanding the regional accent proved a particular challenge on both ends. It seemed that our Kenyan counterparts were not fully aware of our intentions and it proved a challenge later on in the implementation phase. There were also clarity issues with our travel itinerary. There were times that we were unsure about what we would do once we arrived in Kenya. There was a key concern of making sure that
the graduating students would be able to be back in time for graduation, leaving us with only a week to get our project completed. While I am not privy to the behind the scenes aspect of the project, I cannot state with full confidence how the communication problems came about or how severe they were at the administrative level. As students we were aware that certain pieces of the project were not coming together and this caused us to be a little uneasy about whether we would be able to implement our design. While this can lead to poor morale, we understood the implications of our work and with the help of our faculty project leader, we pressed forward despite our doubts.

Another issue that weighed on our minds was the cultural impact of our work on the people using the filter. We were made aware from Aqua Clara that fieldworkers tend to have to earn the trust and respect of the people they intended to help. One key aspect of our design was the use of copper to disinfect the water$^{2,8}$. Apparently, the users did not trust the use of chlorine in their drinking water due to its unfamiliar taste. Even when using the copper, the fieldworkers had to assure the users that the copper was nontoxic. The fieldworkers equated the copper to being similar to ground up belt buckles and not some other material intended to cause negative side effects. With regards to removing excess fluorine, we knew that aluminum and calcium would react favorably with the fluorine and help the filter decrease the concentration$^{6,9}$. Since we were aware of the distrust that people had towards the use of copper and chlorine, we did not consider using aluminum and decided to go with calcium. The calcium would be supplied in the form of bone char. Since the people using the filter would be of an agrarian background, bone char from cattle would be readily available. Due to their familiarity with those animals, it was our assumption that they would be more welcoming to using a filter based on a local resource. This further showed us that the nontechnical issues would play a heavy role in our project. Our contacts in Aqua Clara also made us aware of the gender dynamics when educating the users. Kenyan culture is more patriarchal and as such we had to be sensitive to include women’s traditional role of gathering water in our project and to ensure that the educational aspect of our project could be gender neutral. To help alleviate the cultural strain, we invited speakers from Kenya to explain some of the finer points of their culture to us. We also attended a GEP seminar regarding international travel and culture shock. It was very reassuring to know that the program was paying attention to the nontechnical aspects of our project and recognizing their importance.

Implementation

Eventually, the semester wound down to the final weeks before leaving to implement the design in Kenya. As stated earlier, our class was constrained by having to fit travel and implementation ahead of graduation. That roughly gave us two travel days to get to Eldoret by plane with an overnight stopover in Nairobi, nearly four days to construct the filter, and a full day’s travel to return home. The trip began with a rather severe thunderstorm in the Midwest grounding flights in and out of Detroit. After being told that our flight to Amsterdam would be held for us, we had to change our itinerary for an overnight stopover in Amsterdam instead of Nairobi. Upon reaching Detroit, we were not allowed to board our Amsterdam flight and we had to settle with
spending a long night in the Detroit airport. After hours of negotiation with customer service, we were able to get on a flight from Detroit to Boston. From Boston we would reach Amsterdam and connect to our Nairobi flight. We were now one day behind schedule. We were relieved to board our flight in Boston, but unfortunately this was the time that the volcano in Iceland was erupting, disrupting flight paths in and out of Europe. Our flight to Amsterdam was longer than usual. Once we arrived, we discovered that we missed our flight to Nairobi and we would have to spend a day in Amsterdam. We lost another day of work. To make the most of our situation, we left Schiphol and explored downtown Amsterdam for the day.

The majority of us were tired from our long travel so our site-seeing was kept to a boat tour and dinner. The next day we flew from Amsterdam to Nairobi and upon landing in Nairobi, we discovered that we could not get new flights into Eldoret without splitting up our group. Our faculty leader was very calm in handling the affair. It was decided that we would keep our overnight stay in Nairobi followed by a six hour van ride through the Great Rift Valley into Eldoret. There was never an outburst of negative emotion from either students or faculty. All we were concerned about was making it to our destination and working on the filter. We had lost two days of significant work time. As we traveled through the Kenyan countryside (Figure 5), we talked about what we had to accomplish with our design and the students came to understand that we would have to put our construction skills to the test.

![Figure 5. Taking a quick stop on a scenic spot of the Great Rift Valley. Photography by Jeff Wojcicki. Reprinted with permission.](image-url)
Once we finally arrived to the site, we noticed that the school was in an agrarian setting. The main courtyard behind the school contained a small herd of cattle (Figure 6). Luckily the school was close to the Kesses Reservoir (Figure 7), so it had a spot of land reserved for pumping enough water from the reservoir to the school and the surrounding community. Next to the pumping station was an immense pile of sand that we had to sieve by hand (Figure 8). Across from the pump were outhouses. The tank that was to be used for our filter had already been purchased there in Kenya and was ready on site for use.

![Implementation site next to cow’s pasture with St. Catherine’s Girls’ School in the far background.](image)

**Figure 6.** Implementation site next to cow’s pasture with St. Catherine’s Girls’ School in the far background. Photography by Bruce Cooley. Reprinted with permission.
We had a small meeting regarding what we had to do to accomplish our goals in time:

1. Assemble hand sieves (Figure 9).
2. Sieve sand into coarse and fine grades (Figure 10).
3. Wash gravel and sand (Figure 11).
4. Place aggregates into filter with collection pipes (Figure 12).

**Figure 7.** The Kesses Reservoir. Photography by Tiago Forin.

**Figure 8.** The pile of sand to be sieved next to the hand sieves. Photography by Jeff Wojcicki. Reprinted with permission.
Figure 9. Constructing the hand sieves. Photography by Tiago Forin.

Figure 10. Sieving sand into fine and coarse grades. Photography by Tiago Forin.
As a class, we knew how daunting it would be to perform those tasks on our own. Moi University students who were interested in water resources were there to help us along. Due to the time of year and the geographic location of our site, rain was frequent although not so much that it hindered our progress (Figure 13). The rains did prevent our shuttle from taking us back and forth from the school so there were times we had to trek for a mile in mud carrying our supplies, again slowing down progress.
The days we had in Kenya went by with stunning speed. After all, we understood the gravity of not completing the filter. It meant that time, effort, and money would have been spent needlessly and that we would have let down the intended users. As a team we understood that if the filter was not fully assembled by the time we left, the filter would never be completed. Every minute that passed on the site had us sieving and washing aggregates and layering them in the filter. While we had no choice but to quickly finish our work, our Kenyan hosts were expecting us to be guests at a peace conference at Moi University and at a reception given at the girls’ school. They were amazed at how diligent we were in our construction efforts. If the school did not provide food for our lunch, I doubt we would have stopped. The last day eventually came and then our project received its final blow. Apparently our flight from Eldoret to Nairobi was canceled. We quickly dumped all the aggregates in the filter and finished construction, albeit in a haphazard way (Figure 14). We had little time to collect ourselves before we hopped on vans to take us on another six hour journey through the Great Rift Valley. Upon reaching Nairobi, the trip followed the itinerary to the letter and we returned in time for commencement.

**Figure 13.** Working through the frequent rain showers. Photography by Jeff Wojcicki. Reprinted with permission.
Figure 14. Putting on the final touches for the filter. Photography by Tiago Forin.

Ending our Project

Given the length of our trip back to Nairobi, it allowed us to discuss the implementation phase of the project. In essence we realized how vastly unprepared we were for the factors that were at play. Given the time constraints we had placed in the beginning of our itinerary, we could not have been dealt a greater blow than the cascading delays we faced en route to our site. These delays forced us into a near tunnel-vision view of our project. Either we get it done, or we fail. While the filter was completed, there was no immediate telling whether the hasty construction adversely affected its performance. On a cultural level, we had little opportunity to interact with other Kenyans, particularly those who were directly affected. While I believe we maintained enough contact with them to not be considered rude, I do not believe we had enough of a cross-cultural experience. Most of our conversations occurred during the construction of the filter and
it was not feasible to take parts in the meetings they hoped we would attend. As we assessed our experiences, we came to understand that something was missing.

Ultimately, we were faced with the question, “What exactly did we accomplish?” What was the purpose for our endeavor? I shared with my colleagues that what we did was put forth an effort to give more time to the people of that community. Time in this sense, would be the time to pursue self-development. Since our filter was serving a school, the end product would be to give cleaner water to the students and staff there. That cleaner water would carry less chances of causing intestinal distress from diseases like cryptosporidiosis. These diseases in children require lengthy recovery times and being caused by parasites, a child can be frequently infected. With an uninterrupted education, these children have the opportunity to improve their status in life. In this way we accomplished “time”, time for students to spend studying rather than recovering from disease. This is what I felt was our greatest contribution.

Discussion

In light of our experiences, I have learned, as an aspiring educator, what an endeavor such as this requires. It requires students who are whole-heartedly dedicated to the project and that are willing to meet the challenge that such projects carry with them. Engineering students must be aware of the influences of non-technical issues and must acknowledge the cultural differences that will affect their performance. All faculty and administrators involved must maintain good communications with one another. The students should be met by a unified leadership that can give useful information to the students and give clear direction for the project. Perhaps the most important aspect is to time the project realistically. Having a project scheduled for research, prototyping, and implementation should plan in extra time for unanticipated delays and complications. Having extra days in all phases of the project leaves a buffer for students not to feel pressured and to develop the project in a manner that is most professional. While these kinds of projects tend to be large, complicated, and demanding, they do provide students a unique opportunity to develop as engineers and to gain an appreciation of their craft and place in the world. I hope this first hand view from a student prospective can provide useful insight to engineering educators and project administrators as to what opportunities and challenges are involved with international service projects. I have also realized that much can be done to help students develop critical awareness around global engineering design capabilities. With this in mind, the following paragraphs summarize ways for engineering educators who are engaged in similar projects can use this paper as a resource for helping their students learn through a global engineering service project.

One suggestion is to provide opportunities for students and educators to discuss, at a deep level, what to expect regarding global service learning projects and what can be learned from them. For example, this document can be coupled with other resources such as Caroline Baillie’s Needs and Feasibility: A Guide for Engineers in Community Projects1 and Donna Riley’s Engineering and Social Justice13 which describes the impact service projects may have on the public. Using
James Mihelcic’s *Field Guide to Environmental Engineering for Development Workers* is another good method for educators to engage students in thinking about doing engineering in different cultural contexts.

I would also recommend that students engage in reflective practice such as photo journaling. A photo journal of students’ experiences can be an important mechanism for helping them reflect on their experiences – the nature of the experience, the challenges they faced, and what they are coming to understand about what it means to be an engineer in global service projects. This paper may serve as a guide for how students could conduct their own photo journal, come to terms with their actions and help shape them to be more aware of the issues revolving around global engineering. Reflective practice can occur at the individual and group level, therefore I would encourage educators to take the time to discuss with their students the reflective pieces they have collected and what it means for them in order to further develop the students’ ideas. Personally, the experience of writing up a photo journal for public use has been an intensive learning experience that greatly amplified my original understanding of global engineering service projects. I hope that the same practice can help others who seek out these global experiences.

Acknowledgements

I would like to thank Dr. Ernest Blatchley, III for leading this project through everything that happened, Anne Dare and Mary Schweitzer of the Global Engineering Program for handling and organizing the behind-the-scenes elements of our travel, Scott and Claire Rumpsa of Aqua Clara for teaching us the filter construction methods and supporting us on site, Dr. Robin Adams and Victoria Laudeman for offering a critical eye to this paper, and Jeff Wojcicki and Bruce Cooley for allowing me to use their photographs. I would also like to thank the other students on the team for their devoted efforts to implement this project.