CONSTRUCTING SLOW SAND FILTERS:

Engineering Students' Experiences in San José de Playón, Bolivar, Colombia

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ABSTRACT

Sol Park, Sanyukta Gokhale, and Kaylyn Colinco were members of a Global Design Team (GDT) involved in providing innovative solutions to drinking water treatment in rural areas of developing countries. The immediate goal of the GDT in May 2016 was to deliver large slow sand filters (SSFs) to a rural school in Colombia. The experience placed the students in a small town 80 km (~50 miles) south of Cartagena, Colombia, called San José de Playón. The town pumps water from the Arroyo Reservoir, which is then consumed by the citizens and students at the local school (the only one in town) without any treatment. Students and faculty at the University of Cartagena hosted the GDT to work with the school for a week. The project consisted of building the SSFs and teaching the school staff about disinfection methods. The simple yet smart design of the SSFs was ideal for teachers and children at the school, but collaborative work with NGOs and local community leaders will be necessary to provide clean water for years to come. From speaking rudimentary Spanish with the schoolchildren, to drying the sand and constructing the actual filters, every step of the project was enriching. The experience raised awareness and compassion for all humanity, sharing what can be shared for the benefit of the greater global community, and the notion that all people are one entity regardless of ethnic, cultural, and socioeconomic backgrounds.

KEYWORDS

global engineering program, slow sand filter, drinking water, water quality, Colombia

INTRODUCTION

Purdue's Global Design Teams (GDT) combine science, engineering, and service to provide students with a unique hands-on experience to solve some of the grand challenges of science. According to the United Nations (2013), 783 million people lack constant access to clean drinking water, and 2.5 billion people do not have facilities for adequate sanitation. Lack of water sanitation results in epidemics around the world, from cholera in Haiti in 2011 to right here in the US like in Flint, Michigan, just this last year (Webster, 2011). The clean drinking water GDT at Purdue University is a class lead by Dr. Chad Jafvert and Dr. John Howarter that focuses around a slow sand filter (SSF). In a slow sand filter, bacteria consume the organic matter in turbid water, resulting in clean water that can be consumed safely with a disinfectant such as chlorine. The spring 2016 class consisted of students developing designs to mechanize parts of the filtrations process in three projects. To meet the demands of these three projects, the class was divided into three teams who generated contemporary solutions, drawing from previous classroom experiences. All three of the products had the potential to be utilized for real application.

Surprisingly, in a class of just 11 people, each of us were on different teams and got to know each other during the trip. Sol's group built a man-powered rope pump to

Figure 1 (above). School community and student teams spreading out sands to dry under the sunlight.

overcome elevation between the water source and the school. Sanyukta's group created an automatic disinfection device to ease the disinfection process for students and teachers at schools. Kaylyn's group constructed a heating oven for filter production to enhance productivity.

Most of the prototypes were built by the end of the semester, however had not gone through adequate testing to be implemented during the summer. Currently, students in the class this semester are further improving our designs to make them a potential option for the future. We were three students from varying disciplines and backgrounds who had never formally met before. A passion for the project and enthusiasm throughout our class lead us to San José de Playón, a small yet beautiful town in Colombia.

DESCRIPTION

San José de Playón is about 82 km (~50 miles) south of Cartagena. Primarily a rural area, many of the families earn less than Colombia's minimum wage and live in modest conditions. With a population of 5,122, the town consists primarily of farmers, ranchers, and fishermen. Its economy is dependent on the cassava, rice, banana, bean, avocado, and palm oil crops. A spirited community, many people are involved in improving the town. The Institución Educativa Técnica y Agropecuaria de San José de Playón is a primary and secondary school that provides an education for students ages 5 to 18. The school has struggled with providing a constant supply of clean drinking water to its students. There are two ways that the school attains drinking water, both of which are sporadic. The first method involves pumping water from the Arroyo Grande reservoir. However, Playón is unable to maintain the equipment required to maintain a steady supply of water. The second method involves collecting rainwater and storing it in a tank, a project funded by a Swiss NGO. Unfortunately, the water collected during the rainy seasons is not adequate to sustain the dry seasons.

Two students named Wendy Garcia and María José Rivas, undergraduates from a research group at the University of Cartagena working on improving water quality in rural areas, contacted Dr. Jafvert to collaborate. The project was designed to utilize SSF to provide clean drinking water to the San José de Playón community. The students and faculty at the University of Cartagena had previously visited the school, organized the transportation, and started the communication with the village. Thanks to their preparation, the sand to be used for the filter was already laid out next to the school and we were ready to start the process upon arrival. Our team brought materials from the US such as trommels, lumbers, nuts, and bolts to construct SSF. The various tasks consisted of drying sand, filtering it through two trommels of different sizes, and separating the sand by size. Building the filters was a collaborative effort between teams from two universities, both of which consisted of students with the drive for hard work and commitment. In addition to building the filters, it was important to teach the school staff how to chlorinate the filtered water to make it safe. As a result, there were two large SSFs completed for bringing clean water in turn of feeding dirty water. Since SSF involves biological process, it was expected to take some feeding time for the filter bed to stabilize to perform its role of removing organic matter.

COMMUNITY IMPACT

The team led under the supervision of Professor Edgar Quiñones from the University of Cartagena prepared a lot of the materials and planned a lot of our itinerary and in Colombia. Because of the existing relationship between the two universities, María José and Wendy were able to meet with Dr. Jafvert at Purdue and begin planning the trip a few months in advance. They were able to provide us with everything we needed. The only issue with them providing local materials was the quality of the sand. The sand was locally bought and sat outside for a long time. As a result, the sand required large amounts of water to clean it, and even after a few weeks, the water didn't come out completely clear; usually the filters only take a week or two to become clear. Currently, students at the University of Cartagena are continuing to research the properties of the local sand and how they affect the filters. Regardless of this, the filters have decreased the turbidity of the reservoir water,

Table 1. Water quality results of the filters (García & Rivas, 2016).

Sample	Turbidity (NTU)	Color (PCU)	pH (Units)	Fecal Coliforms (UFC/100mL)
Influent (Water from the Reservoir)	10.8	106.00	8.24	100
Effluent with Chlorine	1.82	71.00	7.53	0

Figure 2. Students and faculty from Purdue University and University of Cartagena with students and teachers of San José de Playón.

as shown in Table 1. However, in order for it to meet the color standards in the US for clean drinking water, the color must be less than 15 PCUs. If the school continues to feed it with reservoir water regularly to clean out the metal content in the sand, the water will be safe to drink.

Despite the poor water quality and the lack of available supply chain, the collaboration between community members in San José de Playón and the research group at the University of Cartagena made the project a success. Although each member played a small role in the grand scheme of the project, the work of each person on the team was essential to building the filters in the limited time frame. As we improve the water quality and its supply, we also hope that the project empowers community members to apply new ideas and technology and to collaborate and help other communities that have not had a chance to improve their current situations. The positive assumption is that the students in San José de Playón who helped us construct SSFs will also be able to help other communities who would like to utilize the SSF method for clean water in the future.

STUDENT IMPACT

Working on a project for a semester and then actually getting the opportunity to implement a design that would help people was an incredible experience. The children at the school were friendly, joyful, and excited to learn about the project and work. However, between the three of us, we spoke conversational Spanish, and the dialect spoken in Playón was different from any Spanish learned in school. Even the students from the University of Cartagena struggled with the speed and diction spoken by the children. The language barrier was the most prominent. However, we were able to find a way to communicate with the children, and each day, we recognized each friendly face, eager to help and keenly observe the process. Kaylyn's experiences in particular, having taken Spanish throughout her schooling, were slightly different. Her testimony is as follows: When I studied abroad in Spain, I spoke Spanish to locals and definitely improved. However, in Colombia I had to explain a technical process to children in Spanish. It's already difficult to explain things to children in English, and adding another language forced me to really think on my toes and get creative. Not only did my Spanish speaking skills improve, but also my people and cross-cultural skills.

For all three of us, it was easy to get impatient with the language barrier and the slow process of building the filters. The sun seemed to be constantly beaming on us, there was no air conditioning, and none of us had never really done heavy labor before. The drive back to Cartagena from Playón consisted of taking naps and selfies and goofing off, all of us sweaty and exhausted. However, interacting with the schoolchildren and teachers was a huge motivation to work hard. Each day, waking up at 5 a.m. and working for a majority of the day got easier, as we grew eager to see our work actually make an impact.

In terms of the actual process, the biggest issue we had was the need for the sand to be dry to run through the trommels. Since the sand was outside for a week with a lot of rain, the sand needed to be spread out in the sun and dried before it could be used. Additionally, the sand had a high content of organic matter. As a result, the water in the SSF was murky and initially unclear. We suggest using cleaner sand in the future, which would result in cleaner water immediately. What we learned from the process is that things don't behave exactly how you think they will according to science and planning.

Figure 3. Students from Cartagena and Purdue jumping with Arroyo Grande as background. (from left to right: Sol Park, Kaylyn Colinco, Sanyukta Gokhale, Maria Jose Rivas, Aura Hernandez, Yineth Garcia Diaz, Wendy Garcia).

There were barriers we hadn't considered during the planning that complicated the process. Each of us had always been interested in providing clean drinking water, but getting to implement a design was a truly unique experience. The joys of working with an amazing team as well as the struggles of drying the sand and planning our schedule around the weather all contributed to an unforgettable week.

Figure 4. Dr. Jafvert (left) and Sol demonstrating sand sifting process using trammel to children in San José de Playón.

Aside from academic work and study, the opportunity to join GEP and solve problems different locations of the globe allowed us to realize the true meaning of what it is to be an engineer. Out of all the classes we take, from the differential equations class we may have struggled with to the photography class we might take to fill an elective, no amount of schooling can replace the one week spent in Colombia. Our degree is directly correlated to helping others; it is what we do and it is the core of what it means to be an engineer. The entire week provided a different view of seeing what is important, what is actually gained by studying the way we do, and how it is beneficial for everyone. The experience building SSFs helped all of us develop a better understanding of the water treatment process. However, a bulk of what was gained from it was compassion, love, and understanding towards other people—the ability to cherish quality time interacting with people from different cultural and socioeconomic backgrounds. We learned from watching the locals live their daily lives, seeing their untainted happiness and their drive for improvement. The learning from them is priceless, and given the opportunity, we would return to Playón in a heartbeat.

CONCLUSION

This experience ignited in all of us a greater passion for engineering and service. Although the GDT class we took was very hands-on and practical, actually implementing the project in a community was even more educational and inspiring. There were setbacks and complications that aren't fully understood and considered when you're in a classroom setting. Although the work was hard and unexpected, each of us gained a further passion and excitement for service projects and water treatment. Our personal testimonies follow.

Sol

The learning from the experience positively affected my current life and choices that I make. My interest in water treatment processes and technology and community services has deepened, and I can still remind myself of the love and pure kindness I felt over the week I spent in Colombia. I will try to go the extra mile to continue my field of study to become an engineer who can help others and share knowledge. As a first step, I am planning to participate in an internship working on a wastewater treatment plant for better disinfection techniques this summer.

Sanyukta

Being a part of the GDT was an unforgettable experience overall. Although the process is relatively simple, there are various speedbumps along the way. This project is one that I would repeat in the future, and I would be interested in leading a project of my own. There are many steps necessary other than simply building the filters that contribute to the process. From transporting any necessary materials to communicating with the members of the community, each step is important. I would be interested to see the process through its success. Many communities around the world could benefit from an SSF. It is a relatively simple process, and given the resources and a team, it is a feasible project to accomplish. One thing I learned was that the ability to troubleshoot when an issue arises is important throughout the process. This not only requires the engineering skills learned in a classroom, but also a group of people who have the drive to make the project successful. In Colombia, we were fortunate enough to work with a community that was passionate and wanted to implement change. The members of Playón were helpful and welcoming, and they were invested in what we were doing. The students from the University of Cartagena, led by María José and Wendy, had an incredibly diligent attitude that went above and beyond to make the process work. If the experience has taught me anything, it is that community involvement is the biggest part of successfully implementing a project. We were so fortunate to be surrounded by a group of people who were hardworking, intelligent, and lighthearted and who made the experience an

Figure 4. Sand-washing process with the help of students at San José de Playón.

absolute joy. I can only hope that when I get the opportunity to lead my own project, I will be so lucky.

Kaylyn

Like Sanyukta, I am interested in implementing this in other countries and definitely going on another trip. Although I have visited the Philippines several times to visit family, I had never thought that I could use my engineering and projects skills to impact the community while I was there. As I plan future trips, I am considering reaching out to the communities I visit beforehand and partnering with locals to teach and empower them to come up with and build solutions for their specific needs.

Not only has this experience greatly influenced our lives, but it's also impacted the community and schoolchildren who will benefit from this water. The schoolchildren were able to learn about the water they're consuming and how they can create and maintain their own water solutions. It was also great for the students to meet people from around the world. Since Sol was from Korea, the children were fascinated by her and her culture. María José and Wendy told us that the children still asked about how we were doing. Seeing the opportunity that university students have to travel and meet people from all over the world inspired the children to work hard in school.

In the past, the Purdue GDT has been able to build filters in countries all over the world. However, the model of partnering with students from students at the nearby university eased the implementation of the SSFs and increased the educational impact. The students from the University of Cartagena continued to visit the school and monitor the progress of the filters until they graduated. They have since passed the project on to other students who hope to continue the progress of the filters and continue partnering with the GDT. Although we are no longer a part of the GDT, there are new Purdue students who are continuing to improve the SSFs. While the trip only lasted a week, it started a partnership that will continue through new generations of students from both universities for years to come.

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AUTHOR BIO SKETCHES

Sol Park, a master's student in civil engineering, **Sanyukta Gokhale**, a senior in environmental and ecological engineering, and **Kaylyn Colinco**, a senior in chemical engineering, all share a passion for developing unique solutions for the global water crisis. They were members of a Global Design Team (GDT) involved in providing innovative solutions to drinking water treatment in rural areas of developing countries.

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