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Water Supply in Developing Countries: Student Experiences in the Dominican Republic

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WATER SUPPLY IN DEVELOPING COUNTRIES:

Student Experiences in the Dominican Republic

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ABSTRACT

In 2010, the United Nations established access to safe drinking water as a basic human right; however, many areas around the globe still lack access. The interdisciplinary service-learning course “Water Supply in Developing Countries” was established at Purdue in 2012 to address the complex issue of water insecurity around the world. Over the past five years, the course has produced teams involving students from nursing, engineering, agricultural economics, biology, and food science working together to develop sustainable, community-scale drinking water treatment systems. In partnership with Aqua Clara International, the student team in 2017 established a drinking water treatment system at the Ana Julia Diaz Luna primary school in the rural community of Las Cañas, Dominican Republic. In addition to the focus on a physical water system, they also collaborated with local educators to design a water, sanitation, and hygiene (WASH) education program. Students guided development of sustainable economic strategies to utilize the system for generation of revenue to reinvest in maintenance and improvements. The observations and lessons learned from the completed stages of this project have been applied to improve the effectiveness and efficiency of subsequent interventions.

KEYWORDS

water, water treatment, drinking water, developing countries, international development, capacity building

INTRODUCTION

In 2000, the United Nations (UN) presented the Millennium Development Goals (MDGs) to ensure an equitable future for all by establishing targets for expansion of access to basic human rights across the globe. In 2015, the United Nations built on the progress of the MDGs by creating the Sustainable Development Goals (SDGs) to outline global access goals for basic human rights for the subsequent 15 years. Within these global targets provided by the UN, access to potable drinking water has been a key feature. Specifically, the MDG to halve the global population without access to an improved water source was the foundation for the SDG that aims to ensure available and properly managed safe water for all by 2030 (UN, 2015).

The Dominican Republic (DR) was selected as an area of focus for this work based on the need for improved access to safe water in rural parts of the country. In 2007, 86% of rural homes were within 15 minutes of an improved water source, which was a significant improvement from the 50% who had access in 2002 (ENDESA, 2007). Though this improvement was a step in the right direction, improved water, as defined in the MDG, does not require water to be microbially safe (Grady, Kipkorir, Nguyen, & Blatchley, 2015). There also remains a need to reduce travel time to a safe water source. Further, the University of North Carolina ranked the DR 113 out of 117 on the Water, Sanitation and Hygiene (WASH) performance index, which ranks countries as a sum of their performance in water access, water equity, sanitation access, and sanitation equity (Cronk, Luh, Mason Meier, & Bartram, 2015).

Many organizations have attempted to address the complex problem of providing global, equitable access to safe drinking water. Unfortunately, these projects fail at a rate of up to 90% due to their complex nature or lack of upkeep (Schweitzer, 2009; UNICEF & WHO, 2011). Only 23% of the systems established by the DR National Institute of Potable Water (INAPA) and the Peace Corps in this area are predicted to be sustainable long-term. This evaluation is based on a multitude of factors influencing sustainability, including activity level, participation, governance, and financial durability (Schweitzer, 2009). As a result of these findings, our team has highlighted the importance of building an interdisciplinary group of collaborators willing to cross academic lines on all aspects of the project to develop sustainable, community-scale drinking water treatment systems.

DESCRIPTION

The Water Supply in Developing Countries course began in 2012 as a collaboration between Dr. Ernest Blatchley III of Civil Engineering and Environmental and Ecological Engineering, Dr. Ken Foster of Agricultural Economics, Dr. Vicki Simpson of Nursing, and Dr. Bruce Applegate of Food Science and Biology. Dr. Blatchley taught a similar class in the 2010–2011 academic year comprised entirely of engineering students constructing water systems in West Africa. After this experience, Dr. Blatchley realized the necessity of approaching the problem of safe water access in an interdisciplinary manner and was inspired to seek faculty from key disciplines to form the current elective class, which is still currently offered. Since its inception, the course has fostered and relied upon student leadership to generate direction for the project. Students with backgrounds in nursing, agricultural economics, biology, food science, and various engineering disciplines have used their academic expertise to contribute to the course. This interdisciplinary approach allows for a comprehensive view of the complex problem of providing community-scale drinking water to rural DR communities. Faculty for the course act as mentors to the students with regard to operating professionally in an international environment, solving logistical challenges, and providing experiential wisdom in challenges within their field of expertise. While students routinely work in interdisciplinary teams, they often are given opportunities to apply expertise from their specific fields. For example, engineers have led efforts to create durable and simple systems that can provide safe water under the given set of constraints specific to each community. Economists have proposed business models to advise the communities if they choose to generate revenues from

the system for maintenance funding and improvements. Food scientists have created sensory surveys to evaluate individual community preferences on the taste of treated water. Nurses have worked with local health clinics and developed health education curricula to be taught in local schools in the DR. The diverse backgrounds of students participating in this project have been crucial to allow for the ability to adapt to and overcome specific community obstacles. Having students from many academic and social backgrounds has produced a course structure that fosters the collaboration between disciplines on all aspects of this project.

The class is structured so that everyone meets once per week to discuss the progress of the project, while other work is done outside of class in small, focused group meetings. Weekly class discussion topics vary throughout the semester; however, the majority of the class is spent on project administrative assignments and updating all participants on project phases. Class time is managed by students, and the class meetings serve as a forum for discussion regarding the project operations and direction. In addition to the class agenda, students lead all planning and execution of specific tasks in order to prepare the project for implementation upon travel to the DR. Currently, class participants are divided into sub-teams that meet for several hours outside of class to address the following assignments:

- improving the completed pilot treatment system in Las Cañas,
- gathering the necessary information to design and implement water treatment systems in additional communities of the La Vega province,

Figure 1. Landscape of the La Vega province. This image was taken through a fence at the primary school in the community of El Mamey in the DR. El Mamey is an adjacent-neighboring community to Las Canas.

Table 1. Selected results from household survey of the Las Cañas community in 2013.

SURVEY RESPONSES (100 households)	PARAMETER	RESPONSE
	Average Household Size	~6 members
	Children (Under 15) per Household	2
	Access to Electricity	All but 1 Household
	Primary Source of Drinking Water	Rainwater or Bottled Water
	Rainy Season	51% Rainwater
		40% Bottled Water
	Dry Season	36% Rainwater
		38% Bottled Water
		14% Protected Deep Boreholes
	Treatment of Drinking Water	81% Reported Treatment
	Method of Treatment	Bleach

- creating WASH education curricula for the schools,
- maintaining communication with stakeholders in the DR,
- establishing a monitoring and evaluation framework for the project, and
- publishing knowledge generated from the project's processes and impacts.

This approach requires students to assume many responsibilities to complete the team-specific duties and allows them to contribute to aspects of the project that interest them the most. Moreover, the division of responsibilities necessitates communication and collaboration between all teams and individuals to maintain progress within the project.

The geographic focus of this project has been the community of Las Cañas, in the La Vega province of the DR. Las Cañas was chosen as the initial community partner through discussions with Aqua Clara International and Rotary clubs in the La Vega province. Upon initial visits with Las Cañas, it was made clear that safe drinking water was a priority for the community. This rural community consists of approximately 300 households, one health clinic, and the Ana Julia Diaz Luna primary school, which serves kindergarten through eighth grade students. Many households in this community are positioned near the school, while the rest are sparsely positioned on the outskirts of the community. The mountainous terrain of the La Vega region creates situations where houses that are close to one another are often difficult to travel between, making transportation challenging at times (Figure 1). From our interactions with the people of Las Cañas, we have found them to be incredibly kind, genuine, and hospitable. This is often

displayed through the sharing of their culture by means of food, community gatherings, and their eagerness to engage in conversation in both English and Spanish. As a community, they have even set up English lessons in the evenings to improve their ability to communicate.

This connection between our team and the community of Las Cañas has been fostered by our years of interaction. However, when this project first began, we knew little about the community with which we would partner. Thus, we generated and received IRB approval for a survey to be administered at households in the community to allow for a better understanding of their socioeconomic status, general health, and interaction with water on a daily basis. Some key results from this survey are presented in Table 1. Data indicated that a large number of households used bottled water as their main source of drinking water. This suggested that a sustainable water treatment system would provide economic incentive for households to adopt safer water, due to the difference in projected cost of our system compared to the price of bottled water. Information from this household survey, along with communication with leaders in the community, allowed us to begin the process of tailoring a water treatment system design to the needs of Las Cañas.

Further, during a trip in 2015, course members conducted microbial tests using most probable number (MPN) analysis to detect the presence of coliforms and ascertain the safety of water within the community. Water directly from the source well in Las Cañas resulted in an MPN of 17.1/100 mL, or “High Risk/Possibly Unsafe” according to World Health Organization (WHO) standards, while water that had been treated by the system resulted in the safest score of zero (WHO, 2011).

Our initial water treatment project in Las Cañas was designed to create an accessible and economically viable source of safe water to the residents of the community. Throughout the development of the pilot system in Las Cañas, and continuing to present day, the project has been a collaborative ideation and review process engaging students, faculty, and local community partners. After discussion with local stakeholders, the Ana Julia Diaz Luna Primary School was chosen as the location of the pilot water treatment system due to its central location and importance in the community, both of which promote system access, maintenance, and use. The Las Cañas system was constructed in 2014 at the school (Figure 2) with an initial goal of providing potable water for children during the school day and the potential to serve as a new, accessible option for potable water to households. Throughout the design process, students from diverse disciplines have contributed their expertise to plan and build this system across a strong crosscultural working relationship. Community engagement has been an integral factor for the successful construction in Las Cañas, and therefore a large emphasis in the project has been placed on involving the communities in each phase of project development. After identifying and building relationships with members of the Las Cañas community, we built relationships with key stakeholders. Looking

forward, we will continue to foster strong relationships to emphasize community commitment and presence by continuing open communication in regard to improving and maintaining the system.

COMMUNITY IMPACT

Ultimately, through the design and adoption of the water system and education programs, this project aims to positively affect health and foster community independence. Within the project team, our long-term community impact goals are to increase access to potable water, reduce cost of water to the schools, and generate demand for potable water within the community of Las Cañas. These objectives were determined by assessing community needs through various conversations with local stakeholders. Additionally, as more systems are built in the surrounding area, we aim to increase intercommunity collaboration. Networking between the communities allows for the sharing of information and solutions to various problems. Consequently, we will promote community independence and progressively reduce the need for involvement from our team.

One method of measuring community impact will be evaluating long-term use of the system, which involves

Figure 2. Las Canas community members with the Purdue team at the celebration for the water treatment system's completion in July 2014.

maintenance, continued WASH education, and community investment. We have created operation manuals and guidelines to aid in maintenance of the system as well as to provide solutions to challenges that may arise due to long-term use. By supplying the community with these tools, our team of students has attempted to foster independence in the community through the shifting of responsibilities. We will continue this pattern over time and reduce our presence until the communities that we work with are operationally independent. This relies on community members to invest in their own health and wellness by taking responsibility for the system. To promote community investment, our aim has been to increase the demand for safe water through education.

It is essential to the long-term success of this project that community members of Las Cañas understand that clean, safe drinking water is important to health and wellness. We created educational materials covering WASH-related topics including waterborne illness, safe water storage, and the uses of clean water to enhance this connection. The goal in developing these materials was to highlight the importance of safe drinking water as well as safe health habits, such as handwashing, which would then act as an incentive for community adoption of the system. This educational approach to safe water has sought to establish the connection between water and health outcomes in the community to generate demand for safe water.

Finally, our project affected the community by building interest in the creation of a sustainable economic plan, thus influencing the use and distribution of water from the system. Sustainable economic strategies were developed by our team and presented to leaders in the community to allow them to choose the most culturally appropriate plan for the generation of revenue. This revenue would serve as input to a maintenance and emergency fund, as well as to generate capital for desired improvements to the water treatment system. Components of these strategies included three different approaches for system management: (1) leasing the system, (2) giving ownership to an administrative group of key stakeholders in the community, or (3) placement of ownership in the hands of the school. Each plan detailed information about who controls what aspects of the system, who profits from the system, cost analysis of each process, and who has direct ownership of the system. These strategies aided in financially maintaining and improving the system in Las Cañas.

To critically evaluate the impact of our project, we have begun development of objective monitoring and

evaluation metrics. Through surveys and observations, we will evaluate how the educational materials created by our team have affected students' behaviors in the communities with which we work. The evaluations will also be utilized to measure if the students in the school act as agents of change by spreading knowledge and enthusiasm about safe water to their families. We will also continue to monitor the impact of our education initiatives while constantly trying to improve our multi-faceted approach. With the lessons learned in Las Cañas guiding our planning for future systems, we will be able to more effectively structure our relationships and prepare communities before construction occurs. As part of clarifying the impact of maintaining and managing these water systems, we plan to more extensively train community members in maintenance and financial management and provide them with written materials that make those learning processes easier. This will address one of the largest challenges faced in Las Cañas: the lack of community preparedness for long-term sustainability.

STUDENT IMPACT

Formed and advised by faculty focused on student development alongside project implementation, the team is student-led, from weekly meetings to late-night design sessions to fostering relationships with community members in the DR. As an interdisciplinary, student-driven initiative, Water Supply in Developing Countries presents students with an environment oriented toward growth and development—personally, professionally, and as leaders. The project challenges students in new ways, requiring work in a dramatically different culture, often in the students' second language. These challenges come in a

Figure 3. Six of the ten members of El Patronato, with one member from the Purdue team in front of the water treatment system at Ana Julia Diaz Luna Primary School.

variety of forms, both at home and abroad, and the skills and knowledge gained through those experiences have the ability to empower and enable students moving forward.

Student leaders play a vital role in the development of the project: each sub-team, as described above, identifies one individual who will lead their efforts to address challenges. This system forces students to expand their leadership skills, pushing their teams to create practical, effective solutions to varied challenges, from low-energy water treatment to effective behavior change. Each of these interdisciplinary teams brings together a different array of skills and knowledge and takes a unique approach to problem solving. Often, disciplinary problem-solving techniques or frameworks, like nursing's "5 A's of Accessibility" or engineering design matrices, are modified, expanded, and applied to problems beyond the scope of any one discipline. While working in an integrated environment with students of such different backgrounds and disciplines, individuals learn new skills with every new project, from public health education planning, to engineering design methods, to economic impact assessment development.

As a whole, the team has formed its own body of knowledge, frequently learning from anticipated and unexpected challenges alike. Some hurdles, like water taste, have highlighted previously unclear dimensions of the project, while others, like community development, were known to the team from the onset, but have grown beyond the scope of original solutions and continue to prove difficult to address even when facing them head-on. These two areas of interest, water taste and community investment, will be treated as a case study in the next section; by examining the history and context of the problems, it is possible to illustrate the engagement and problem solving fostered in student participants in the project.

Taste and Community Investment: Case Studies in Student Impact

In initial meetings with the community of Las Cañas, many people made it clear that having safe water was important to them. The Purdue team believed this expressed enthusiasm was sufficient to begin the planning and implementation process for the pilot water treatment system. To foster a community sense of ownership of the system, a self-identified group of community leaders called El Patronato assumed responsibility for the system (Figure 3). This group agreed to maintain and operate the system as well as to be the main decision-making entity with regard to managerial and financial

aspects. The Purdue team worked with El Patronato on how to define proper operation and maintenance of the system and provided written, illustrated instructions in Spanish to augment these discussions. After implementation of the system in Las Cañas, periodic communication was maintained with El Patronato while the Purdue team was back in the United States. After several months, it was communicated that the system was no longer being used by the school or the rest of the community. Upon discussion with El Patronato, there appeared to be two main causes for the lack of use: a poor taste due to the groundwater source feeding the system and the lack of a proper environment for system adoption.

A local well was originally determined the ideal source of water for the pilot treatment system after taking into consideration several design factors and community leader input. It was communicated to the Purdue team that the taste of the treated water was "metallic" due to water hardness, which was unacceptable to the community populace. In our initial decision-making process, we believed that having drinking water that was reliably free of contaminants held more importance than the taste associated with groundwater. This experience taught us that our priorities did not always match those of the community members, and in fact, taste was very important. To address the disagreeable taste, plans have been developed to integrate collected rainwater into the established treatment system to provide safe water without a mineral taste. These changes to the system will be implemented in May 2017, with the goal of improving the taste without sacrificing the quality of treated water.

One of the primary challenges associated with international service projects is to properly engage the community and promote their investment in the changes that are being made. This investment may take the form of financial investment or internal motivation to implement and adopt a new practice. As this project focuses on the DR, a developing country, requiring financial investment from the rural communities was not the Purdue team's objective. Instead, an approach was taken to provide information and work with community leaders to increase the community's demand for safe drinking water and generate motivation to adopt change. Leaders from El Patronato communicated that one of the key factors that limited use of the system after implementation was the lack of government certification. Community members have a strong trust in government approval and made it known that trust in the system would be limited until it was approved by a Dominican authority. Once modifications to the pilot system in Las Cañas have been made, we will help coordinate approval of the treatment system

by the Dominican Republic Ministry of Health and the National Water Supply and Sewage Institute (INAPA).

CONCLUSION

Throughout this service-learning project, benefits to both students and community partners have been clear and are key features of the course. Students involved in the Water Supply in Developing Countries class are immersed in a well-developed, interdisciplinary environment where innovative ways of thinking are required. The complexity of the problem and the holistic approach to addressing access to safe water requires individuals to work beyond their expertise and become familiar with each aspect of the solution. Students gain experience in project management, leadership, intercultural communication, and professional writing, in addition to discipline-specific skills that relate to the different components of the project. Ultimately, this class prepares us for addressing wicked problems outside of an academic setting, as real-world challenges require well-rounded individuals with the ability to effectively collaborate.

Implementing the pilot system in the community of Las Cañas provided invaluable lessons for us to consider as we plan to expand our impact in the La Vega region of the DR. Much of our initial focus in Las Cañas was based on establishing relationships within the community and designing their water treatment system. Upon reflection, we realized that we should have done more to understand how people in the community interacted with their current water structure, thus allowing the new water treatment system to be tailored to their current habits. Additionally, we learned that more effort and resources should be devoted to engaging the community and expanding dialogue between community stakeholders and our team. With this insight, we can explore the needs of a community beyond water and adapt a solution to directly address more than the need for water.

The communities that we have decided to work with next were selected based on a decision matrix, which addressed the lessons we learned from the pilot system in Las Cañas. The potential for a good communication and leadership structure within the community were weighted as important factors in this matrix, whereas the technical details of the project were evaluated as factors that could be easily overcome. This perspective was based on recent, regular communication with community leaders in Las Cañas that has allowed progressive, incremental improvements to be made to their system so that it can become fully utilized. Designs are being finalized and funding sought to integrate a rainwater collection

system into the treatment process at Las Cañas as well as to pursue other small modifications to adapt the system to meet community preferences. These changes will be implemented in May 2017, while data collection and follow-up conversations relating to the changes will be used to inform future system development. Moving forward, the team will continue to extend its partnerships in the region and will create unique treatment systems in three communities over the course of the next three years. During the upcoming trip, the team will work to finalize preliminary system designs with community partners, including treatment mechanisms, distribution systems, and maintenance and monitoring plans. While we are currently applying these lessons to our work in new communities, we hope to also inspire other groups to learn from our successes and failures in addressing this complex, global challenge.

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AUTHOR BIO SKETCHES

Albert Alwang is a second-year master's student in the agricultural economics department and expects to graduate in May 2017. His thesis research examines the causes and consequences of migration on Malawian farmers. Alwang plans to pursue a career in international development.

Margaret Busse is a doctoral candidate in civil engineering with a focus on environmental engineering. Her bachelor's degree in biological engineering and master's degree in civil engineering were both earned at Purdue. She is pursuing a career in academia to continue working on projects and exploring technologies to bring safe water to developing countries.

Audrey Caprio is a junior in the Purdue School of Nursing with a specific focus in global public health nursing. With a plan to graduate in May 2018, she hopes to join the Peace Corps and be involved in international health care. Caprio has contributed to the Water Supply in Developing Countries for one full semester and plans to be involved in and facilitate the project in the fall of 2017.

Marieke Fenton is a master's student in agricultural economics with an expected graduation date of May 2017. She plans to continue to a doctoral program with a focus on international development. Prior to beginning her graduate degree at Purdue, she served in the US Peace Corps in the community health sector in Paraguay and has lived and worked across Latin America including in Mexico, Colombia, and Peru.

Jason Hawes is a senior in environmental and ecological engineering. After graduation in May 2017, Jason plans to complete a master's degree in the Ecological Sciences and

Engineering program at Purdue University before pursuing a doctorate in interdisciplinary urban sustainability. Hawes is an eagle scout who has endeavored to apply his engineering expertise through public service both in the local community and abroad.

Andrew Kanach is a doctoral candidate in the Purdue University Interdisciplinary Life Science (PULSe) program with a focus on microbiology. He plans to graduate in May 2019 and aims to pursue a career in consulting after gaining experience in industry. Kanach has been an active contributor to the Water Supply in Developing Countries class for five years.

Autumn McElfresh-Sutton is an undergraduate student in the Purdue School of Nursing, with an expected graduation date of May 2018. She plans to pursue a career as a critical care nurse. McElfresh-Sutton has been involved with the Water Supply in Developing Countries class for one semester and plans to travel with the class in May 2017. She will actively participate in the class for the following three semesters.

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