

## **Experiential Service Learning: Applying Engineering Skills and Knowledge in the Dominican Republic**

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## Abstract

Service-learning projects can make a positive impact on an engineering curriculum by providing students with valuable hands-on experiences that incorporate aspects of various engineering disciplines. Carrying on a years-long tradition, Mercer University students spent three weeks in a rural area of the Dominican Republic where they performed projects related to civil, environmental, and industrial engineering. Working with local water council representatives, students were able to hear first-hand the challenges rural communities have in accessing clean drinking water. They then participated in the construction of an aqueduct system to provide drinking water to these underserved communities. They learned how to test the drinking water for contaminants such as nitrates and E. coli, which led to training locals on water testing. Students surveyed community members to evaluate community attitudes toward disability, interviewed people with disabilities or their caregivers to understand their needs, and investigated opportunities to improve accessibility in this rural community. For some students, the experience left them with a desire to continue their involvement, and several have committed to come together to finish a ramp design to improve accessibility in a facility for our in-country sponsor. Through course evaluations, all students indicated that the experience was a valuable, life-changing experience, which greatly enhanced their engineering education.

**Keywords:** service-learning, multidisciplinary engineering, drinking water access, accessibility

## Introduction

Service learning provides students with an opportunity to apply the skills they are learning at a university to a real-world, hands-on community problem. Within engineering education, service learning can provide students with the “softer” skills such as teamwork, social awareness, and global impact of engineering deemed necessary by Engineering Criteria 2000 established by Accreditation Board for Engineering and Technology (ABET) [1]. According to Oakes, to be most effective, service learning should not be an add-on volunteer experience to the curriculum, but rather an integrated experience that complements and enhances the curriculum [2]. There are four characteristics of service learning: service, the academic connection, reciprocal partnerships, and reflection [3].

The service provided can take many forms. It may include a community project, community education, or the administration of a community survey to understand what problems need to be addressed [4]. The academic connection refers to the learning aspect students gain through coursework and hands-on experiences, and is oftentimes, multidisciplinary. The reciprocal partnership between the university and the community partner must be beneficial for both. One challenge of service learning versus traditional capstone projects is that a meaningful, ongoing relationship with the community must be maintained [4]. In addition, many projects cannot be completed in a single course and need the buy-in from the local community to ensure their long-term success [4]. The final piece of service learning is reflection. Reflection is vital for students

to understand their civic responsibility and is most often assessed through reflective journaling [5].

In 2007, Mercer University began combined study abroad and service-learning programs to “provide life-changing experience for students through academic instruction, cultural immersion, applied research, meaningful service, and spiritual reflection” [6]. Since its inception, there have been 163 trips to 45 different countries. Although the service-learning programs vary throughout the different university disciplines, the format typically consists of a pair of professors taking 10 to 20 students internationally to perform a service-learning project. Students enroll in the program for two summer classes, which typically count toward their elective requirements.

The specific program to the Dominican Republic began in 2015 under the leadership of Dr. Michael MacCarthy to address the need for providing access to drinking water in the rural part of Dominican Republic near the town of El Cercado, see Figure 1. Since then, the program has expanded to not only address the need for access to drinking water (2015 to present), but also to evaluate the impact access to drinking water has had on rural communities (2022) and to address community attitudes toward people with disabilities (2023 to present).

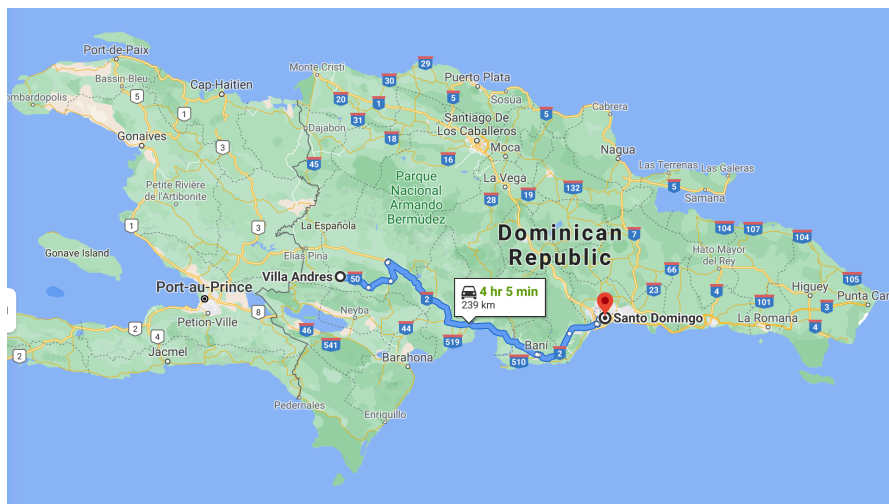


Figure 1: Service-Learning Location in Dominican Republic

For the 2023 Dominican Republic service-learning program, students enrolled in two summer classes:

- ECV 491 – Water, Infrastructure, and Appropriate Technologies in Developing Communities and
- ISE 491 – Accessibility in Developing Communities.

Although the courses reside in the School of engineering, they are open to all majors across the university. In fact, the 2023 trip consisted of 10 engineering students plus 5 journalism students.

The first two weeks of the summer program were spent on-campus providing students with background information required for the three weeks in-country. These lessons included general knowledge of the Dominican Republic, some simple Spanish lessons, lessons in environmental,

civil, and industrial engineering, and engineering for development. The students also learned about reflective journaling and were required to keep a journal during their stay in-country. At the end of the stay, five reflective journal entries were turned in for a grade.

### **On-campus training**

In ECV 491, students learned about drinking water access, treatment, and distribution. Many comparisons were made between drinking water access in the United States versus the developing world, especially the Dominican Republic. In the El Cercado region, most rural drinking water infrastructure consists of a spring source, a spring box (to protect the spring from contamination), distributing water from the spring box through PVC piping to a masonry water storage tank, and then distributing the water through PVC piping to the local community.

During lectures, students learned about Dominican water tank construction and spring box construction practices. They learned the difference between making mortar, grout and concrete, and performed hands-on lab sessions to show them how to make each, see Figure 2. The lab sessions were added to the on-campus training in 2022 after student evaluations showed that students would have preferred learning construction techniques before arriving in-country.



Figure 2: Students mix concrete, grout and mortar

Students also learned about water contamination and treatment. In the Dominican Republic, most of the drinking water comes from groundwater springs surrounded by farmland. Fertilizer contamination is often present even within protective spring boxes which can overflow during seasonal flooding. Hands-on labs familiarized students with testing water for nitrates, suspended solids, pH and E. coli, see Figure 3.



Figure 3: A student testing a drinking water sample

ISE 491 was introduced to the program in 2022 with the goal that year of evaluating the effect of the drinking water program on the communities surrounding El Cercado. To that end, the lectures conducted during the second week on-campus were devoted to the development of surveys, practice conducting surveys and interviews, and an overview of the language and culture of the region. They were also given an assignment early in the first week of class to research and develop a presentation on a specific aspect of the Dominican Republic (demography, flora and fauna, history, culture, agriculture, economy, or politics); they presented their results during the second week.

In 2023, the focus of the ISE portion of the project turned to mobility and accessibility, so students taking ISE 491 learned about issues related to disability, including a brief introduction to the history and models of disability, as well as the challenges that people with disabilities face in different communities. They were also introduced to the use of surveys for gauging community attitudes toward disability and interviews to gain a deeper understanding of the needs of people with disabilities. During the lecture sessions, students also practiced conducting surveys, learned about the specific survey that would be used, and presented the results of the research they had conducted into the history, culture, politics, food, and natural environment of the Dominican Republic.

Two hands-on lab sessions were conducted to introduce students to the observation, design, and building skills they might use in-country. The first lab exercise required students to evaluate the accessibility of several campus buildings and facilities by navigating to and through them while pushing a wheelchair. They expressed some surprise that buildings they used quite frequently as students were either partly or completely inaccessible to someone with mobility challenges (for example, buildings in which some or all classrooms are only accessible via stairs). They also pointed out that many “accessible” facilities required significantly more time and effort to access (for example, ramps that could only be accessed by going around the back of the building or elevators at the far end of halls from accessible entrances).

During the second lab session, students learned the basics of using standard power and hand tools that might be used in-country to construct ramps and practiced laying out ADA-compliant accessibility ramps to give them a sense of the space required (Figures 4 and 5).



Figure 4. Practicing with Hand Tools



Figure 5. Laying Out a Ramp

### **In-country experience**

After two weeks of on-campus training, the group traveled to El Cercado, Dominican Republic, where they spent three weeks. The 2023 group consisted of four professors and 17 students. One of the first items of business was to meet with the members of the water council, which represent the 37 rural communities around El Cercado, see Figure 6.



Figure 6: Meeting with Water Council

Through a translator, students heard first-hand the drinking water related issues these communities face including:

- Inadequate access to drinking water
- Flooding causing springs to shift away from spring boxes

- Damaged water storage tanks
- Asbestos in existing piping
- Spring boxes that no longer capture water due to shifting of the groundwater table
- Farmers siphoning drinking water for agriculture
- Locals siphoning drinking water for a commercial swimming pool

In 2023, the water council meeting determined that the most pressing need was for the construction of a new water storage tank and spring box for the community of Sabana Bonita. Sabana Bonita had an existing 3,000-gallon water tank, which was leaking and inadequate for the 80+ families. In addition, due to flooding, the existing spring had shifted away from the existing spring box and was no longer filling with water. A new spring box was needed to protect the spring and direct water to the existing piping. Working with local community members, students spent the following weeks mixing concrete and mortar, tying steel reinforcement, and constructing an 11,000-gallon masonry water tank and spring box, see Figures 7 and 8.



Figure 7: Students tying rebar (left) and constructing the water tank (right)



Figure 8: The completed water tank (left) and spring box (right)

As noted, the 2022 surveys and interviews focused on assessing the impact of the program on the communities around El Cercado. Six communities were visited on this trip. La Ranca, La

Guama, Pedro Alejandro, and Siembra Vieja are communities that have had household access to water for a number of years due at least in part to the work of previous projects. Los Caños is a community that had been the focus of the program the previous year, and so had household access to water for a little less than a year. Manyai was added after learning from our community partner during our introductory tour that the community had been without household access to water for several years. Approximately 10 households per community were visited, with students conducting surveys (in Spanish) and interviews with the assistance of a local interpreter who was familiar with many members of these communities. They also participated in debriefing sessions and developed summary findings. Figure 9 shows a student conducting a survey with a community member, while figure 10 shows students looking down at the spring that had been the only source of water for the Los Caños community.



Figure 9. Conducting a Survey



Figure 10. Previous Water Source

The results of the surveys and interviews indicated that household access to safe drinking water is critical to the people and communities of El Cercado. Those who related memories of the time “before the aqueduct” spoke of the difficulty involved and the health problems related to carrying the water, and drinking or cooking with unsafe water. A little over half of the people surveyed reported treating tap water before using it for drinking or cooking and many bought bottled water for visitors and small children, indicating an awareness of the potential impact of microorganisms in the water on health.

Overall, in 2022 students expressed varying degrees of discomfort with conducting the surveys and interviews in Spanish, but this discomfort was generally allayed by the end of their first day in the community, once they had some experience with the survey and a degree of comfort with community members. Based on this experience, students in 2023 spent more time practicing the survey questions with the interpreter before going into the communities to conduct their surveys.

In 2023, the focus of surveys and interviews shifted to developing an understanding of community attitudes toward disability, and to interviews with people with disabilities and their caregivers to identify specific needs. As in the previous year, students traveled in small groups to



a community and took turns conducting the surveys with the residents there. The survey used in 2023 was a Spanish translation of the Attitudes to Disability Scale (ADS), developed by the World Health Organization [7]. The survey consists of sixteen statements about people with disabilities and asks the respondent to rate them on a five-point Likert scale (“Strongly Disagree,” “Disagree,” “Neither Agree nor Disagree,” “Agree,” or “Strongly Agree”). It is designed to measure attitudes toward disability on four scales: Inclusion, Discrimination, Gains, and Prospects, and was developed and tested in a cross-cultural environment. The survey is used to identify needs and opportunities to develop education and information strategies around mobility and accessibility in the community.

Because “Dominican Spanish” and the standard Spanish spoken in Latin American countries differs, the survey was further refined for the communities around El Cercado with the assistance of our interpreter and another community member. Table I provides an example of two of the statements in the survey in English, Standard Spanish, and Dominican Spanish.

Table 1. Standard Spanish and Dominican Spanish Translations of Survey Statements

<b>ENGLISH</b>	<b>STANDARD SPANISH</b>	<b>DOMINICAN SPANISH</b>
People tend to become impatient with those with a disability	Las personas tienden a impacientarse con las personas con discapacidad	Las personas tienden a ser impaciente con las personas con discapacidad
People with a disability have less to look forward to than others	Las personas con discapacidad tienen menos que esperar que otras	Las personas con discapacidad tienen menos esperanzas que los demás

A total of 34 surveys were conducted in 5 communities (La Guama, Siembra Vieha, Pedro Alejandro, Manyai, and Sabana Bonita). In each community, a group of 3 to 6 students took turns conducting the survey, with our interpreter providing translations as needed both to clarify questions and responses and to include comments from respondents that gave additional insight into their answers. At the end of each day, a debrief meeting was held in which students discussed their observations based on that day’s surveys, as well as their suggestions and concerns. Figure 11 shows students administering a survey to a member of the community whose disability was the result of an accident.



Figure 11. 2023 Survey

Top-line results of the surveys were that respondents agreed that people with disabilities are generally discriminated against in society and have a hard time making new friends or engaging in society. They are generally split on the prospects for people with disabilities, with comments ranging from “it’s better to die than to have a disability” to “there are a lot of jobs that don’t require walking.” They are also split on whether people with disabilities are a burden, with a slight majority saying they are a burden on their families and an even split on whether they are a burden on society (with more than one of those who disagreed saying, “the government does nothing for people with disabilities, so they are not a burden!”)

Based on these results and their own observations while taking the surveys, the students suggested questions to ask during the in-depth interviews. These questions focused on the interviewee’s perception of disability and their unique situation, as well as how they perceived the support and acceptance they received from their family, community, and the larger society. The interviews were structured around these questions.

A total of six interviews were conducted, three of which were with women who were the caregivers for their children with disabilities (ages 9, 23, and 32), and three of which were with men who had acquired a disability due to illness or accident. Interviews were conducted by the faculty member, and all students observed at least one interview, taking notes and providing additional questions as appropriate. These interviews provided important insights into the perspectives, expectations, and needs of individuals with disabilities and their caregivers. They all affirmed that they had received personal support from family and friends, ranging from visits and food to transportation. They also articulated their need for help obtaining medicine and other basic needs, as well as the difficulty of attending school and getting around in general on unpaved roads and broken sidewalks. They also relayed stories of both support from their family and community and times when the family and community did not believe in their ability to succeed with their disability.

Because this was our first trial of the survey and we had a relatively small number of respondents, we chose not to perform additional analyses on the results of our surveys and interviews. During future visits, we will continue the surveys with a focus targeted groups (older residents, students, professionals, etc.), and institute a separate survey for people with disabilities to identify needs and perceived barriers.

A final meeting was held with the students after all interviews were completed to discuss our results and observations. As one student noted, “We aren’t going to be able to do anything about infrastructure problems or lack of government support for people with disabilities,” so our discussion focused on paths forward that include small projects to help individuals and small groups, as well as identifying and addressing needs for education and advocacy in the community.

One final activity underscores the value the students placed on their experiences during the trip. Our community partner expressed a desire for the students to build an accessibility ramp at Villa Andres, the compound where we stayed, so that the facility could be made accessible for visitors with disabilities. While we did not have the time or materials necessary to complete the task during the trip, a group of students undertook to evaluate the site and develop a preliminary

design. This group brought their ideas back to campus with them and have worked throughout the fall semester to create a final design that will be built during the 2024 trip.

## **Student Evaluations**

End of course evaluations were used to evaluate student perceptions of the two courses. Questions ranged from answering statements with strongly disagree, disagree, neutral, agree, and strongly agree; to open-ended questions such as “What did you like about the course?” and included space to provide general comments about the courses.

In ECV 491, when students were asked to evaluate whether “The course stimulated my interest in the subject”, 28% agreed and 71% strongly agreed. When students were asked to evaluate whether, “The course as a whole was a worthwhile experience”, 100% strongly agreed. Similar results were seen in the evaluation of ISE 491, with 86% strongly agreeing to both “The course stimulated my interest in the subject” and “The course as a whole was a worthwhile experience.”

When asked “What did you like about the course? What would you leave unchanged?”, one student answered, “I wish I could have stayed another month. I loved the experience so much”. Three students commented on how useful the on-campus labs were, with one student stating, “I felt that the on-campus labs did a good job preparing us for the work in the DR”. Students also expressed satisfaction with the on-campus lab activities, with one noting, “I liked the interactive parts like going to walk around campus to test for accessibility and seeing firsthand how little changes like wider doorways or multiple accessible entrances/exits would help immensely.” Only one student expressed dissatisfaction with the survey portion, writing in part, “I did enjoy the construction side of the trip better because we were able to see a direct and immediate benefits to the community.”

When asked for general comments about the course, one student wrote, “I absolutely loved this MOM and class experience. This trip sparked my interest even more in civil engineering, and it affirmed my choice in major. I am so glad I choose to do this trip, and I wouldn't change a single part about the overall experience.” Another wrote simply, “It was a great trip change nothing.”

## **Conclusions**

The service-learning projects in the Dominican Republic were a valuable blend of environmental, civil and industrial engineering which enhanced the engineering curriculum at Mercer University. The projects incorporated the four aspects needed for a successful service-learning experience – service, academics, reciprocal partnerships, and reflection. The students used their engineering knowledge to work with local community members to improve their lives and reflected on their experience through reflective essays.

With respect to the mobility and accessibility aspect of the project, the first foray into community surveys and interviews provided great insight into community attitudes and the needs of people with disabilities and their caregivers. Several potential infrastructure and individual projects were highlighted that may be undertaken in future trips. Surveys and interviews in future trips will be

structured to ensure that younger adults and students are represented, as well as to gather information from older adults regarding their support needs.

## References

- [1] E. Tsang, J. Van Haneghan, B. Johnson, E.J. Newman, and S. Van Eck. "A report on service-learning and engineering design: service-learning's effect on students learning engineering design in Introduction to Mechanical Engineering". *International Journal of Engineering Education*, 17(1), pp. 30-39, 2001.
- [2] W. Oakes. *Creating effective and efficient learning experiences while addressing the needs of the poor: an overview of service learning in engineering education*. In 2009 Annual Conference & Exposition (pp. 14-381), June 2009.
- [3] M. Lima. *Service-Learning: Engineering in Your Community*. Oxford University Press. 2014.
- [4] A. R. Bielefeldt, K. G. Paterson, and C. W. Swan. "Measuring the value added from service learning in project-based engineering education". *International Journal of Engineering Education*, 26(3), pp. 535-546, 2010.
- [5] R. G. Bringle, and J. A. Hatcher. "Implementing service learning in higher education." *The Journal of Higher Education*, 67(2), pp. 221-239, 1996.
- [6] <https://www.mercer.edu/global-impact/mercero-mission/> [Accessed Jan. 15, 2024]
- [7] M. J. Power, and A. M. Green. "The Attitudes to Disability Scale (ADS): development and psychometric properties". *Journal of Intellectual Disability Research*, 54(9), pp. 860-874, 2010.