Experiential Learning Abroad: A Critical Survey of Two Programs

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***Abstract*— International experiential learning programs are becoming increasingly common and can be complex in both format and content. Due to the complexity of these programs, highlighting lessons learned is a critical activity for future program growth and improvement. In this vein, our paper highlights and learns from two international experiential learning activities in engineering, both at the undergraduate level, that focused on water supply infrastructure: one, a project-based experience in an urban setting in Amazonia Peru; the other, a mixed project and course-based experience in rural Chile. Overarching lessons learned from both programs relate to in-country partners, trip preparation, and interaction with local people. Site and partner selection that builds upon relationships and the clear articulation of expectations from both sides is critical for success. Both programs also highlighted the value of intensive trip preparation, including course organization, pre-trip team meetings, book studies, learning the local language, and meetings with local partners. Both programs suffered in their own way due to lack of meaningful interaction with one local people group or another. Throughout the paper, we highlight further insights and implications, whether unique or cross-cutting, and link these to recommendations for future international experiential learning program development.**

Keywords*— *Experiential Learning; Engineering for Social Justice; Sustainable Community Development; Project-based Learning; Humanitarian Engineering

I. Introduction

Global Engineering (GE) focuses on the design and execution of appropriate engineering-, management-, and technology-based solutions and strategies for healthy, sustainable and equitable infrastructure systems in developing country contexts. GE, as a field of engineering, has been gaining increasing relevance and precedence following the advent of the UN Sustainable Development Goals (SDGs). The SDGs clearly highlight interconnected targets for healthier societies through institutional and infrastructure based solutions rooted in sound and innovative practices and advancements in engineering, management, and technology. The SDGs offer both an exciting and daunting opportunity for engineering professionals and practitioners to apply their skills to challenging global issues. Equally, if not more importantly, the SDGs push institutions of higher education to equip these professionals with the skills to navigate, and adapt to, the inherent complexities they will confront in global projects, while at the same time disseminating best practices and frameworks for pedagogy, research, and practice in the area of GE.

As institutions of higher education continue to embrace experiential learning programs focused in international service learning projects in general and global engineering pedagogy in particular (e.g., Engineers Without Borders, Engineers for a Sustainable World, etc.) this paper seeks to contribute to the conversation on practice in this area of pedagogy. Here we compare and contrast two experiential learning programs. Program 1 is a senior design capstone project in Nauta, Peru. Program 2 is a mixed project and course-based program which took place in Santiago, Chile. Both international experiential learning programs focused on water service provision and sustainability. In comparing these programs, the authors seek to answer the following overarching questions as they relate to experiential learning programs and engineering education:

- What aspects of these programs worked well and were most beneficial to students?
- What lessons were learned that can be applied to the broader arena of international experiential learning programs, whether course or project-based?

In the sections that follow, highlights and lessons learned are discussed for both programs and conclude with cross-cutting remarks for future programmatic pursuits.

II. PROGRAM 1: Senior Design Capstone Project in Nauta, Peru

A. Program and Project Background

In 2017-2018, a Senior Design team from George Fox University (GFU) was formed to assist JungleMasters Ministries (JMM) and BMS-World Mission with a water supply project in Nauta, Peru. The GFU Senior Design

program is similar to many schools - a two-semester class in which teams of 3-6 seniors are partnered with two advisors, generally one GFU professor and one adjunct professor who is currently working in industry. A real-world client with a real issue tasks the team with an engineering challenge that becomes the capstone project for these students. In this case, three seniors were advised by a civil engineering professor from GFU and a local professional engineer working in the water resources engineering field. The program is dual purpose: first, to allow students to bring together all of their engineering skills and apply them to a real-world project, and second, to meet the client's stated goals and objectives. Because of this second purpose, the pedagogy of the program is more of a "wrapper" that fits around the project and the client's goals, in that it takes whatever form it needs to ensure that learning occurs while also meeting the client's needs. The first semester (fall 2017) was spent data gathering, scoping, and meeting with representatives from JMM and BMS-World Mission. The field visit took place over Christmas break December 2017 to January 2018. The spring semester was spent developing the final design, final drawings, and a final report with recommendations for improvements.

Nauta is a city of between 30,000 and 40,000 people located very near where the Maranon and Ucayali rivers join to form the Amazon River, approximately 100 km south of Iquitos. The large majority of the city has no sewers or septic and no piped water. The dominant form of water supply are small wells and stand-pipes located throughout the city where residents can bring buckets or other containers to fill. There is one neighborhood within the city called La Union, which has around 80 houses. BMS-World Mission has a training center located in this neighborhood. In 2014, BMS-World Mission constructed a water system as a ministry to serve the residents of the neighborhood. The system consists of a well with an electric pump, rainwater cistern and pump, water tower with several fiberglass tanks (shown in Figure 1), and transmission pipeline down the main street, with individual houses connected to the main pipeline. JMM works closely with BMS-World Mission and helps to maintain the well and pump. Construction of the system was largely done via BMS-World Mission funding, but residents were required to purchase materials to connect to the transmission line (0.5 inch PVC pieces), and a monthly service fee is charged for each connection. A water committee headed by community residents collects fees and makes decisions on maintenance and improvements, while volunteers perform various additional duties. Water is allowed to flow out of the tanks to the community two times per day, for roughly 30-45 minutes each in the morning and the evening until the tanks are empty. Members of the community regularly leave their taps open at all times, and when water is flowing they will secondary containers for later use primarily in laundry, hygiene, and cooking.

BMS-World Mission approached the GFU team with four main issues:

1. Low water pressure and supply to certain houses in the neighborhood. Some houses were receiving ample water, others were barely receiving any.

Fig. 1. Water tower in Nauta, Peru. Fiberglass tanks can be seen at the top, and the main transmission line can be seen exiting the bottom right of the photo.

2. low well yield leading to the belief that there was insufficient water to meet neighborhood demands,
3. electricity usage from the pump was high and the pump was running the well dry periodically, and
4. the entire system was manually controlled and many of these controls were located at the top of the water tower, which was unsafe.

The task of the team was to investigate each of these issues and develop a set of recommended improvements to address them.

The GFU civil engineering professor and two of the three student team members conducted the field visit, which occurred over the course of approximately seven days. In preparing for the trip, the team read the book, *Helping Without Hurting in Short Term Missions* and met weekly to discuss the book and talk about entering another culture to do engineering development work. A main goal of the field experience was to collect data and information that would assist in the design. Pedagogical goals included training students in client interaction, user observation, and system operations and troubleshooting.

A number of tasks were completed by the team during the field visit:

1. The team met with and extensively interviewed the local missionaries who knew the system.
2. The team performed a levelling survey along the transmission line route.
3. A well-logger was installed in the well and later retrieved after several days.
4. A detailed schematic of the system, including all dimensions, pumps, valves etc. was sketched.
5. Water quality testing was performed on the well and cistern.
6. Pressure and flow testing was performed at various houses throughout the system.
7. Observations were made of water use types, volumes, and practices throughout the system.

While in the field, another issue was observed by the team and added to the scope, which was erosion. Due to the recent conversion of most roofs in the community from thatch to metal, peak runoff on the road had greatly increased, leading to rutting and erosion around building foundations.

At the end of spring semester, a number of recommendations were made in the final report. The most significant recommendations were:

1. Separate the distribution system into two zones. Separate the two tanks and create two separate transmission lines. Each transmission line would serve half of the system and have its own tank. This would serve to greatly reduce inequity in the system. Modeling data supported this recommendation as shown in Figure 2.
2. Based on availability and client preference, replace the current pump with a smaller, more efficient pump, or continue to use the lowest flow local Pedrollo pump, but in either case, either install a timer switch or a controller (e.g., Pumptec) to turn the pump on and off and protect it from running dry and causing damage to the pump.
3. Add a valve control box to the base of the tower, and make other modifications including directing the overflow of the tanks to the cistern below, installing rebar railings and rope gates on the tower.
4. To address erosion, install rainwater harvesting systems on houses along the main street, dig small channels along the sides of the road and armor them with rock, add planter boxes where possible to slow and spread runoff, and armor the base of the water tower. In the long-term, build a retaining wall at the base of the tower.

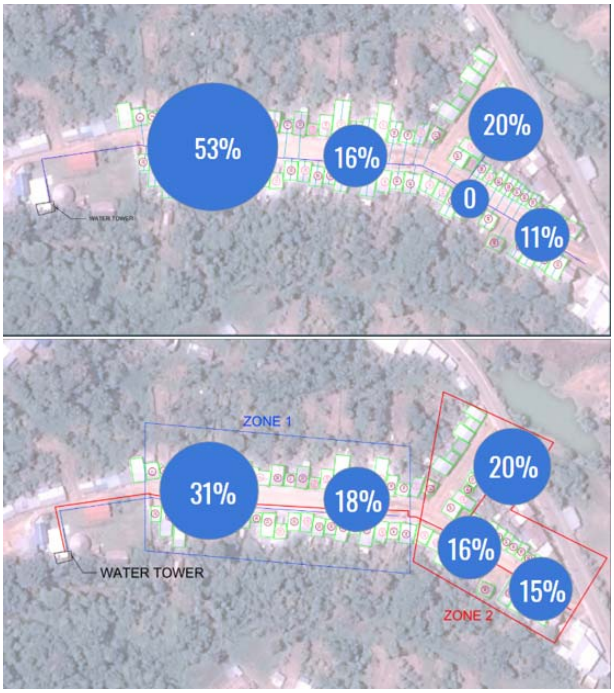

Fig. 2. Modeling results for the existing distribution of water in the neighborhood (top panel), and the proposed two zone solution (bottom panel) distribution of water. Percentages represent the total percentage of the water volume each day that the area received.

B. *Highlights: things to replicate*

Of the many highlights that emerged from the program, the most salient related to i) modeling professional practice vs. allowing students to take this lead, ii) the importance of cultural sensitivity, iii) the importance of supporting a local embedded partner, and iv) the importance of listening to and learning from users and then verifying with observations. We describe these in further detail below.

1) Modeling vs. Guide on the Side: As in the classroom, a balance must be achieved between the professor demonstrating how to tackle a problem or complete a task, and allowing the student to attempt to do so while providing appropriate support when necessary. That said, as mentioned previously, a main purpose of the senior design program is to successfully meet the client's goals and objectives, and thus there is less tolerance for students to struggle through, particularly when it risks failure of the project goals. In the case of the field visit, the professor regularly modeled professional practice and client interaction for the students, and then periodically allowed the students to dialogue with the client and make their own decisions and recommendations to the client about next steps. These are critical skills that are rarely effectively taught in the classroom and are especially necessary and valuable for engineering in developing countries.

2) Trip Preparation and Cultural Sensitivity: As mentioned previously, in preparing for the trip, the team read the book Helping Without Hurting in Short Term Missions and met weekly with Dr. (NAME) and Dr. (NAME) to discuss entering another culture to do engineering development work. This was an invaluable step that prepared the team members to

be sensitive to the fact that they were working in another culture. Main themes of the book that were important included:

1. Put people before project - in fact, the team had bracelets made including the words "People Before Project" on one side and the Spanish translation "La Gente Antes del Proyecto" on the other. People will respond more favorably to people outside their culture conducting development work if they feel like they are more important than the project at hand.
2. Assume things are more complex than meets the eye
3. Look for local resources and abilities already in the community rather than fixating on the immediate material needs.

One student commented with regards to this: *"One highlight was the small and close knit travel team. We had many pre-trip meetings that included team building, talking deeper about the trip goals, cultural differences, and general expectations."*

3) Support A Local Embedded Partner: Knowing that the short duration of the field experience along with the language barrier would hinder the team from effectively building relationships with the people in Peru, the focus became building relationships with JMM and BMS-World Mission missionaries, who were the clients and who themselves have built and are continuing to build relationships with the people around where they live in Nauta. Their presence in the community is vital to achieving community buy-in for the recommended improvements and was vital for the success of our design. One student commented: *"I think the most important aspect that led to a positive trip experience was a strong relationship with our clients who lived in-country and were invested in the project and our trip. The clients were able to give insight and their opinions to guide our recommendations and design."*

4) Listen, Learn, and Observe: As noted above, the client initially believed that there was insufficient water to meet neighborhood demands. Initial calculations, derived from literature based water-volumes per capita for uses expected in the neighborhood, indicated that there should be enough water to meet all of these demands. Key observations in the community were as follows: all household taps were always on, flows were very high in the first few houses on the line and most of this water was allowed to spill onto the ground, and flows were very low near the high point of the system, and especially just following a branch that supplied a lower elevation street in the neighborhood. These observations generally confirmed that there was sufficient water overall, but that the inequality in distribution led to the belief that the low well yield was a major part of the problem. It was the team's belief after making these observations that even with a higher yielding well and therefore more water overall, the problems would remain. Listening to resident's reports of the flows they experience was also extremely helpful in identifying whether low flow was a result of occlusions (sediment or air), elevation, or unequal branching.

C. Things to Improve or Build Upon

While there were several minor and logistical lessons learned, the primary area which could be improved upon was in interaction with the local water-system users. The team had a couple of opportunities to dialogue with members of the water committee for the neighborhood via the client who served as an interpreter, but these were largely unstructured, informal opportunities that were fairly common in the local culture. The lack of a formal, structured meeting prevented user feedback from being rigorously incorporated into the final design, as questions from the design team were not well planned, and responses were difficult to interpret and prioritize as part of the design. Part of the reason behind this was a lack of significant buy-in to the project from the committee. One student commented that: *"though our clients were invested in the project, there was never a strong sense of ownership from the larger community. The water system in place was not something that they were paying significant money for and many people had not paid the client in months. Project or non-project related, I think more interaction with the larger community would be beneficial. It would have been good to build that friendship and trust but hard with the language and cultural barriers."*

III. PROGRAM 2: GLOBAL SEMINAR: SUSTAINABLE RURAL WATER SUPPLY IN CHILE

A. Program and Project Background

In summer 2017 an experiential learning course called a "Global Seminar" (UCB, 2017) was offered for 12 University of Colorado Boulder (UCB) undergraduate engineers at Universidad Diego Portales (UDP) in Santiago, Chile. The course offered an introduction to sustainable rural water service development and management with a focus on water supply systems in rural Chile. Course content was given within lectures, student-led discussions and debates, and presentations, while the experiential aspect of the course involved cultural excursions and visits to community water systems. Lectures and in-class discussion covered a breadth of theory and best practices regarding water quality regulations, source water management, and water distribution and treatment, given by the traveling UCB faculty member and the resident UDP faculty member (NAME), as well as a few guest lectures by other faculty within the UDP civil engineering program. A key focus of the class was on the systems-based conceptualization of social, economic, institutional, and technical factors that can influence long-term functionality of a water system.

A primary component of the course took place outside of the classroom – where students engaged in cultural excursions such as museums and were asked to develop and conduct a short community-level case study research project focused on rural service sustainability outside of Santiago, Chile. In these case studies, student teams saw water treatment implementations first hand and critically analyzed aspects that influenced long-term water service functionality for their community context. As such, the course sought to not only provide UCB students with a solid background for potable rural water supply in a developing country context, but to also provide students the chance to develop and execute a small-

scale research project. Case study design and data analysis were covered in the class to provide students with important tools and techniques. Figure 4 provides the overall flow of lectures, discussions and field work as they took place within the three week Global Seminar.

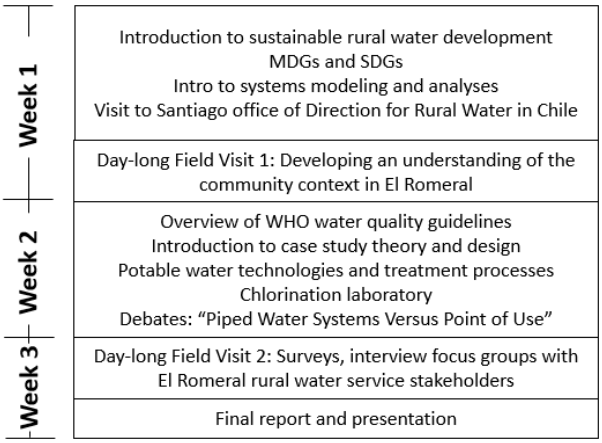

Fig. 4. The weekly breakdown of the Global Seminar class

The case study assignment asked students to break into four person teams to develop and execute a case study protocol outlining justification of and logistics for the collection, analysis and interpretation of data regarding the identification of the "key factors that influence sustainable rural water provision in the community". Students were tasked throughout the project to "think in systems" and to use secondary and primary data to hypothesize a conceptual framing on how the local factors influenced water service sustainability. This project offered a way for students to apply and demonstrate their knowledge regarding what it takes to ensure sustainable rural water services in general and Chile in particular, and to show their ability to think outside of the box about the complex elements driving sustainability.

Students spent two full days visiting the water system, talking with water system operators, and performing interviews and focus groups with community water committee members (Figure 3). With the data from these community visits, teams were able to develop and interpret systems models that represented the interconnection of factors driving the sustainability of rural water services in the community. An example systems model known as a "causal loop diagram" is presented in Figure 5. Students developed a final write-up of their study and gave a formal presentation on high-level findings.

B. Highlights: things to replicate

Based on the instructor's observation of the program, in combination with the feedback that was received from the post-class surveys, the positive student takeaways worth replicating from the class were i) an appreciation of complexity, and ii.) a reaffirmed passion for global engineering.

Fig. 3. Water committee focus groups (top panel), water system visit and conversation with system operator (bottom panel)

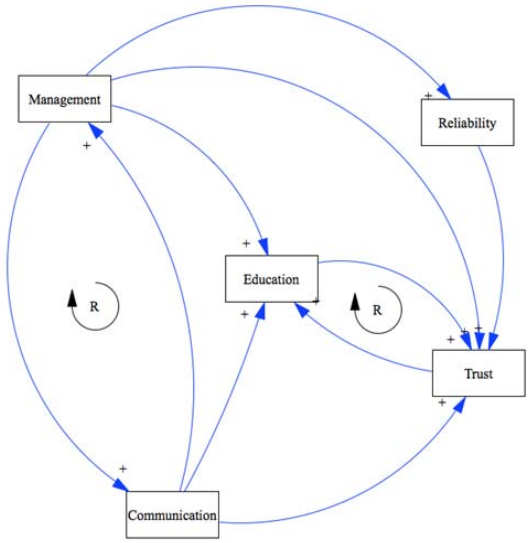

Fig. 5. A systems map (causal loop diagram) developed and interpreted by a student team

1) An Appreciation of Complexity: One important outcome of this program was to have students develop an appreciation of complexity and to demonstrate a few techniques from system dynamics and systems thinking that students could use

to frame and conceptualize these complexities. For the most part, students indicated that the class was successful in this pursuit, where one student indicated,*"I think that this class fully made me understand the complexity of these global engineering projects. It gave me a lot of understanding of how these projects generally go and how to overcome some of the problems that arise."* While the practical means of fostering systems thinking in engineering education is still a relatively uncharted frontier, the emphatic "light-bulb" realizations of students when introduced to the concepts of systems thinking, and the impressive conceptualization of local system complexity they presented in their final projects, provide evidence for the merit of systems thinking and systems modeling in engineering education in general and global engineering in particular.

2) A Reaffirmed Passion for Work in Global Engineering: A strong reoccuring theme in student feedback was that the class allowed them to further realize and reaffirm their passions and desires to do international engineering in developing contexts. As one student stated, *"It [the class] was very beneficial. It gave a good feel for what work in developing communities entails and the challenges surrounding it."* Another student mentioned, *"[The class] widened my world view and helped me decide more what I want to do professionally."* Indeed, a strong motivation for experiential learning courses of this type is to offer an opportunity for students to fully experience and vet their desires to do global engineering work.

C. Things to Improve or Build Upon

Various aspects of the Global Seminar emerged as areas for improvement and reinforcement. These areas for improvement related to: i.) Language barriers, ii.) Balancing activities in and outside of classroom and homework, iii.) Engagement with local students, and iv.) Establishing clear expectations of in-country partners.

1) Language Barriers: While students were told in pre-trip meetings of the importance of Spanish language proficiency for the class, this reality, of course, became far more apparent when they were finally immersed in conversation. A lack of preparation in language acquisition on the part of the students led to suboptimal interactions with UDP students and community members. One student rightly mentioned, *"I could have communicated with the communities more effectively. Perhaps help students before hand to know engineering terms in Spanish? This shows that need for students to focus strongly on their language skills as a primary priority before going on trips."* Indeed, an obvious oversight by students (and even faculty) is the importance of knowing the local language - both from lack of experience, as well as the inherently difficult and time-intensive task of learning a language, in the midst of so many other competing priorities. Depending on the desired level of student engagement with the local population, students should have their language proficiency evaluated before being offered the chance to travel. In addition, one of the faculty members, either at the home or partner institution, must be fluent in the local language in order to evaluate student language proficiency and coordinate course logistics.

2) Balancing Activities in and Outside of the Classroom: A major difficulty of the class was striking a balance between lecture-style classes, group work, homework, and student presentations with cultural excursions and fieldwork. Many suggestions were given by students for how to deliver material while maximizing time outside of the classroom. Once such comment was, *"I think it would be cool to make lectures more interactive and seminar style, and then compact the week into 3 5-hour days (Monday-Wednesday) and leave more time to explore Chile."* Overall, the instructors of the Global Seminar agreed with this assertion, but cannot offer much more than a cautionary note to future instructors to spend considerable time brainstorming how to minimize in-class lectures and activities and maximize time in the field. Afterall, the inherent benefit of international experiential learning is to be immersed in the unique and exciting environment to which they have traveled. An instructor's best intentions to get students out of the classroom often requires first breaking free from the paradigm of lecture-based higher education.

3) Fostering more interaction with local students: Largely a result of a low Spanish language proficiency, students found themselves isolated from the UDP student population. One CU-Boulder student indicated: *"I would have enjoyed interacting with the local engineering students more. I feel an integrated class would have been very useful. Working alongside of them would have been difficult but worthwhile because it helps prepare engineering for working on international teams."* While the onus is on the student to learn the local language, the onus on ensuring student interaction with local students and faculty is that of the instructors. This could have certainly been fostered better for the Global Seminar, perhaps through the engagement of social activities with students outside of the classroom such as hikes, biking, lunches, game nights, dinners. Again, these sorts of exchange activities are limited primarily by students' level of language proficiency, or the English proficiency of local students.

4) Establishing Clear Expectations of In-country Partners: Planning and executing the field-work (case study) portion of the class presented its own set of problems that pointed to the need to have well-vetted and strong relationships with in-country organizations and partners. The primary in country partner for the course was the Directorate of Rural Water Services (APR) in Santiago Chile. APR helped plan and coordinate the community visit with the community water committees. The original intent of the field-work component of this course was to visit a large breadth of communities, each with varying levels of water service functionality and management challenges. Given a number of logistical constraints, the student teams ended up visiting only

three communities, the last of which was clearly chosen by APR to show off their best rural water scheme. On the day of the second field visit with this community, the student and faculty were given "the red carpet treatment," where each person was graciously received with a three-course meal and a gift box with snacks and wine. To be sure, the students and faculty were grateful to the community water committee (and APR) for their hospitality. However, what had begun as a way for students to learn how to extract and analyze meaningful information to perform a sustainability assessment for a rural water system ended as a political campaign for a government agency in need of positive public relations. This situation could have likely been avoided (or at least anticipated) if the Global Seminar planning team had known more about APR and the existing political context of government-run rural water programs in Chile.

While there were certain issues with the fieldwork component, the benefits of time in the field still showed through in offering students the opportunity to gauge and appreciate the true realities in the field of global engineering. Moreover, while the case study itself could have gone smoother, students' exposure to the rural water service technology was highly beneficial, where one student remarked, *"I loved the first field trip out to the rural communities--I loved to get out there and felt I learned so much about the functioning of rural water systems."* Similarly, another student noted, *"I really enjoyed the field visits. I felt the experience gained from site assessment was very important, especially because the communities were sharing with us how they ran and maintained their systems."* On one hand, these outcomes offer a silver lining to programs in global engineering and experiential learning, showing the intrinsic value of cultural immersion that supersedes suboptimal circumstances. On the other hand, however, it shows the great potential for these programs - if executed well with the help of in-country partners - to be a life and career forming experience for students.

IV. CONCLUDING REMARKS AND RECOMMENDATIONS FOR INTERNATIONAL EXPERIENTIAL LEARNING PROGRAMS

As programs in global and humanitarian engineering become more prevalent, it is important to develop an understanding on the best ways to promote student development towards becoming more technically-grounded, culturally agile, and systems minded. While international experiential learning programs are especially well-suited in fostering these learning outcomes, educators in general have much to learn. The two programs discussed herein varied substantially in their approach and objectives, but nevertheless lessons learned from each exhibit several common themes. From these experiences (Program 1 and 2), lessons learned center on the following.

1. Partners: Thoughtful site and partner selection that builds upon relationships and the clear articulation of expectations from both sides. This necessarily requires the investment of time and money on the part of the University to form and cultivate these relationships well before the first student cohort arrives in-country.
2. Preparation: Both programs highlighted the value of intensive trip preparation, which involves work on behalf of the organizers and professors to structure the preparation and trip, but also can include pre-trip team meetings, book studies, language classes, and meetings (via video-chat or otherwise) with local embedded clients or partners. Specifically, the ability for students to speak the local language, even at a low to moderate-level of proficiency, should be a priority that is assessed before travel, as this can have a substantial impact on the quality of interaction between the students and those with whom they interact.
3. Interaction with Local People: Both programs suffered in their own way due to lack of meaningful interaction with one local people group or another. Thoughtful preparation to structure time and objectives for this interaction is recommended for all international experiential learning trips.

Additional lessons learned from one program or the other include: the importance of empowering students with ways to tackle the complex systems influencing the success of their future engineering projects; the importance of listening to local clients/users and observing existing systems; and the utility of these projects in reaffirming students' passion for work in global engineering.

The highlights and lessons learned from these trips will be useful for structuring future experiential learning programs in global engineering.

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