



Knowledge, Skills, and Attitudes Acquired through Engineering Student Experiences Abroad

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Abstract

International engineering experiences facilitate the development of essential skills for students.

This paper identifies areas of student development acquired while working on international engineering projects abroad. These experiences presented a unique learning environment and opportunity to develop and implement a holistic engineering project. The findings from our research indicate six areas of student development: technical knowledge, communication, personal growth, project management, community-based development, and intercultural awareness. These six categories are broken down into subcategories to further identify specific areas of student development.

These findings are based on reflections collected from Engineers Without Borders student members. The first round of data was collected through on site journals and discussions and post-travel interviews with participants of a site-assessment trip to Cameroon and implementation trip to Guatemala. The second round of data was collected through a discussion with seven students leaders of projects based in Guatemala, Cameroon, Haiti, and Nigeria.

The theoretical framework for this study is grounded in experiential learning theories and speaks to the fact that students enrich their knowledge, skills, and attitudes through direct experiences.

While abroad students practiced engineering and project management skills while working alongside community members to address specific needs. The international context often presented language and cultural barriers and challenged students to work in remote or underdeveloped environments. Recognizing this will allow more effective education tools and curricula to be created. The results of this study communicate the value of such international experiences and motivate the integration of these skills into domestic curricula. Further analysis can be found at www.publish.illinois.edu/engineeringabroad.

Introduction

International engineering experiences enhance the traditional engineering curriculum by immersing students in an unfamiliar environment where the opportunity to learn is rich. Due to the complex and often transformative nature of these experiences, such learning can be challenging to quantify and qualify. However, qualitative data from students who have these experiences offer valuable insight into the impact of such learning opportunities. This study looks at students who traveled abroad with the student run co-curricular organization Engineers Without Borders (EWB) to examine and clarify what they have learned, and leverage it for broader educational purposes.

This research focused on the following question: What specific knowledge, skills and attitudes do student engineers say are impacted by EWB international service experiences abroad? A specific objective of the research was to determine how students viewed the impact of these experiences on their developing knowledge, skills, and attitudes as engineers. Although other research has shown a variety of developmental outcomes from student international service projects, relatively little is known about the specific effects participation in EWB projects has on a student's sense of what it means to be an engineer. This paper details the investigation of the effects of student international service projects on six categories of student development: technical knowledge, communication, personal growth, project management, community-based development, and intercultural awareness.

Literature Review

Research¹ has shown that experience enriches and deepens learning. Experiential learning is deep, rich, and transformative because it immerses the learner in tangible reality and requires choices to be made about how to apply knowledge². Experiential learning accommodates the natural trajectory of adult development to personalize opportunities so that overall understanding is deepened³. Experience becomes the conduit through which knowledge is more permanently embedded in the perceptions, emotions, memory, and senses of the learner⁴. Because experiential learning can lead to deeper understanding and a better ability to apply knowledge than academic learning alone, it is a commonly accepted practice in many types of professional education⁵.

Service-learning is a form of experiential learning with a commitment to contribution through civic engagement⁵. According to Zlotkowski, "Service-learning helps promote both intellectual and civic engagement by linking the work students do in the classroom to real world problems and real world needs."⁶ An increasingly common form of education, service-learning has a wide range of outcomes^{5, 7, 8}. Interest in service-learning as an experiential route to deeper and more permanent knowledge has led to research to determine what we really know about outcomes. In their meta-analysis of 62 studies involving over 11,000 students, Celio, Durlak, & Dymnicki found that outcomes of service-learning were statistically significant in five areas: attitudes toward self, attitudes toward school and learning, civic engagement, social skills, and academic achievement⁷. Although service-learning can take many forms, some argue that such outcomes are magnified in cross-cultural, international, complex, or unfamiliar contexts^{5, 9}.

Developing a better understanding of learning outcomes in specific situations may benefit the development of engineers and better prepare them for the future. The "Engineer of 2020" is expected to need strong technical skills as well as socially oriented knowledge, skills, and dispositions that will enable creative problem solving. The Accreditation Board for Engineering and Technology (ABET) and ASCE both acknowledge a change in the work environments

engineers find themselves upon graduation, ones that require strong interpersonal skills such as leadership, teamwork, communication, and globalization^{10, 11}. Research and instructors alike are starting to discuss how engineering service-learning can be used to fulfill the ABET's academic program requirements.

Deardorff analyzes the identification and assessment of intercultural competency and the knowledge, skills, and internal outcomes associated with deepening cultural awareness and personal development¹³. Dym et al. assert the importance of a project-based approach to learning engineering in order to not only teach engineering principles to students but to also foster knowledge and skills in engineering students that include, "working in teams, making presentations to a variety of audiences, and managing design and engineering projects"¹⁴. These skills prove vital in the professional field and can be learned in an international context.

Johnston discusses the importance of including multidisciplinary, culture-based, non-measurable elements of engineering to the current engineering curriculum¹⁵. The necessary people-based approach to development that is culturally sensitive¹⁶ is discussed by Korten, which is seen in the community-based development section of this paper.

The purpose of this paper is to present findings from a study that focused on the student development of engineering students after participating in international experiences with the co-curricular organization Engineers Without Borders. In looking at the literature and data collected for this study, six categories and subcategories of student learning were determined which will be discussed and related to how international experiences prepare students to be effective and successful engineers.

Methodology

This qualitative study used a variety of student reflections to examine the impact of international service experiences on their knowledge, skills, and attitudes. Preliminary results were based on data collected from students who had traveled to Cameroon and Guatemala with the University of Illinois at Urbana-Champaign chapter of Engineers Without Borders. The resulting framework was then checked against a second round of data collection with EWB project leaders and then refined. This approach enabled participants to better grasp their own understanding, further reflect on their learning through international experiences and provide deeper insight into improving the impact of these experiences.

Data Collection

Overview

All participants in this study were undergraduate students actively involved in Engineers Without Borders who were abroad or had recently been abroad for an international engineering project.

For this study there were two rounds of data collection. The first consisted of data collected from 2009-2010 from two Engineers Without Borders project teams both while on-site and upon returning. This included twelve unfacilitated on-site group discussions, ten journals individual students kept while abroad, and seven on-campus post-trip interviews conducted by members from the research team.

The second set of data was collected during a workshop held to generate discussion amongst seven active EWB members about the impacts their involvement in the organization had on their personal, academic, and professional development. The workshop centered around a list of open-ended, predetermined questions designed to provoke reflection on the international elements of their EWB involvement. Participants were given five minutes to compose a written response to each question before the group discussed it as a whole. This process fueled dialogue about their experiences abroad, the impact these experiences had on them, and how the current structure of EWB influenced the experience. Two members from the research team facilitated this workshop.

Background of Engineering Projects

The project teams that participated in the first set of data collection were working on projects based in Cameroon and Guatemala and both focused on improving the community's access to clean water. The Cameroon project was visiting their partner community for a second site-assessment trip. They conducted interviews with community members to better understand their habits related to water consumption and health, attended large community meetings, did land surveying, and participated in a variety of community oriented activities. While English was spoken for some of the communication, translators were also used throughout the trip. The Guatemala project was visiting their community for the second time but had spent the semester prior preparing for the trip. They interviewed community members, constructed biosand filters with the help of local construction workers, and worked with two local social workers on health education programs. Spanish and English were spoken on this trip. Student members who spoke and locals translated for non-Spanish speakers.

Data Analysis

Stages of Research and Analysis:
1. Develop list of key areas of student development based on literature and documents
2. Code first round of data
3. Draw preliminary conclusions
4. Cross check conclusions with second set of data
5. Present secondary conclusions

Table 1: Stages of Study Research and Analysis

Data analysis was performed in five stages using multiple researchers and a hybridized inductive-deductive process to triangulate and verify findings^{17, 18}. After formulating study objectives and the focus question, stage one began with researchers meeting to identify key areas where student development was anticipated based on other research on student participation in service projects abroad. For each key area a term or phrase was chosen and an operational definition assigned¹⁹. This deductive process, created a theory-driven abbreviated codebook²⁰ based on the objectives of the study. Operational definitions defined the parameters of the research focus, established guidelines for coding, and supported consistency among multiple researchers.

Stage two began with a single researcher de-identifying all documents and scanning them to discover any data that related to codes in the codebook. The process of identifying data relating to codes involved multiple readings of documents highlighting the data and then comparing the highlighted data to the operational definition for the code. For this process HyperResearch²¹ (a qualitative analysis software program) was used to track coded passages from the data. Of the 55 documents accumulated in this study, 29 were determined to generate substantial data that addressed the study focus. In stage three an inductive process was used to re-examine those 29 documents to determine the most prevalent and relevant categories given the paper focus. 42 specific areas of student development were identified that were evident in participants. These outcomes were grouped into five main categories (communication and language development, cultural awareness, technical skills and knowledge, appropriate community development, and personal growth). This allowed us to create a working framework that summarized the knowledge, skills, and attitudes impacted by students' international experiences.

Then began the fourth stage: a second round of data collection. Two members of the research team led a guided discussion about the impact of international EWB experiences on their knowledge, skills, and attitudes. The questions guiding this workshop were written in an open-ended format to allow students to direct their response and ensuing discussion. None of the preliminary conclusions were presented to the students at this time. Reflecting on these discussions allowed the research team to better assess the categories and subcategories outlined in the primary findings. After reviewing the data a sixth category (project management) was created and multiple subcategories refined. While the framework is the result of both rounds of analysis the quotes presented in the findings section are evidence drawn from the first set of student reflections. More detailed evidence is described below and can also be found at www.publish.illinois.edu/engineeringabroad.

Findings

The diagram below is a summation of the findings presented in this paper. As concluded from data analysis, there are six major categories in which student development happens as a result of

on-site international engineering experiences. It should be noted that these six categories overlap, and it is not their exclusiveness but rather the distinct role they play in a student's overall development that makes them significant. The categories that compose the larger pie shaped pieces of the diagram include: technical knowledge, communication, intercultural awareness, community based development, and project management. Personal growth was placed closer to the center of the student development diagram to highlight the fact that characteristics of the other five categories foster personal growth. This arrangement is further justified because, for instance, project management cultivates development in leadership and teamwork, which are components of personal growth. The five categories are further decomposed into subcategories, which can be seen in the outer ring of the diagram. The diagram was strategically arranged so that the more similar two pieces of the diagram are, the closer together they appear. Since a number of subcategories were seen as applicable to two categories, whenever possible they were placed in a position so as to overlap the two.

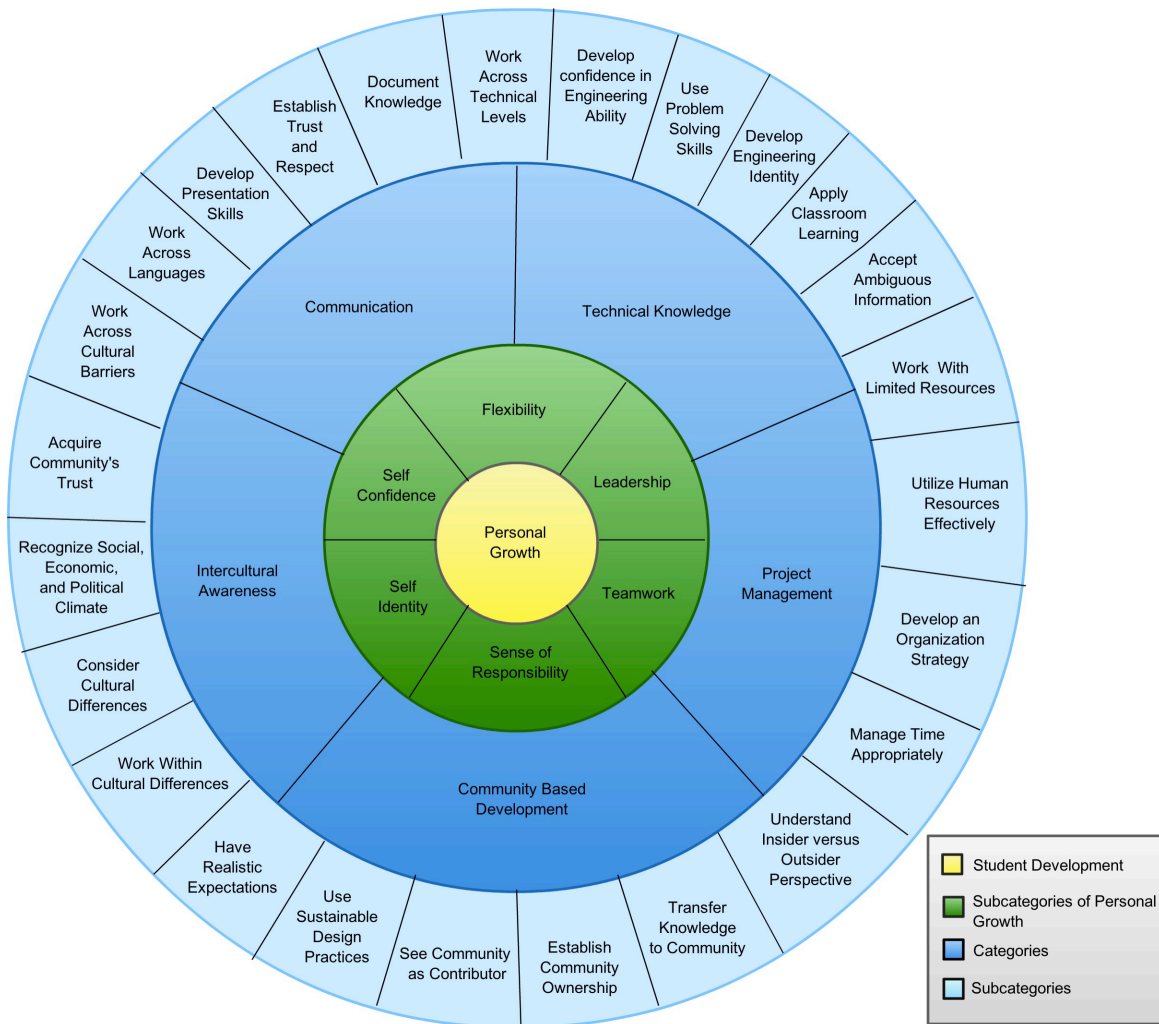


Diagram 1: Student Development from International Engineering Project Experiences Abroad

These categories are not exclusive and many of the concepts within each transcend multiple categories. For example, students in Guatemala had to explain how and why community members should be using biosand filters. This required them to understand the technology (technical knowledge), present the technology in a culturally relevant manner (intercultural awareness) and communicate this across language barriers (communication). The result of which was increased confidence and self-awareness (personal growth).

The six categories are described in further detail with exemplar student quotes that characterize student learning. As an example of the full analysis, the category of communication is decomposed into its various subcategories with supporting evidence and explanations. A detailed analysis for the five other main categories can be found at www.publish.illinois.edu/engineeringabroad.

I. Communication

Learning to communicate effectively emerged as a major component of student's experiences. This area was defined to include any task involving language, communication, or the transfer of knowledge. While on the project, students encountered situations that required them to communicate across language barriers, between different cultures, and with people of varying levels of technical knowledge. Further, this communication was conducted in a wide array of unfamiliar environments. Students presented at community meetings with over a hundred attendants, met with small groups of influential community members to make decisions regarding the project, and entered homes to conduct interviews.

Students expressed they were unsure of themselves early on but became increasingly more comfortable as time went on. This development appeared to be the product of observation and practice, and was enhanced by the ability to discuss social nuances with other project members and preparatory team meetings before certain encounters.

Within this category the following subcategories emerged from student reports: working across cultural differences, working across languages, presentation skills, establishment of trust and respect from community members, documentation of data and information, and working across technical levels.

Working across cultural differences

1. So, that was tough because also the translator wasn't always sure how to make the connection, because I think there are a lot of ideas and concepts that we'd have to spend years there to understand in terms of responsibility or feeling indebted to somebody, gratitude, just some very general, more emotional or spiritual concepts that I think we don't totally understand - or I did not understand after being there for such a short while. -Cameroon Trip Participant

2. The sense of why communication is important both in terms of being able to talk to people, and people just also across cultures; that's something I think I'm going to carry with me. - Guatemala Trip Participant

3. *We know that we had a really good message, but it can be really hard to communicate that across the cultural barriers. So I think that's a big issue that we've been having and that you need to be aware of. We also need to find a better way to express that to our incoming members. Because I don't think that's something that comes across as apparent. Because we always think that – as engineers, we always assume that the people there want this technology, but that's not the case. That's not an assumption that you can just make. So we need to find ways to basically sell this product. Because we know that it's going to improve their health, improve their standard of living. We just have to find a way to express that so that they will continue to use this project. –Guatemala Trip Participant*

Throughout the course of their trips, students encountered cultural differences that affected their ability to communicate. This included physically notable differences such as when to shake hands and more subtle differences such as how to show respect or the role of men versus women. Students noted the additional level of complexity communicating across cultures added to exchanges in various ways as presented in quotes 1 and 2. Especially when implementing engineering products that often involved bringing new technology to the community, the transfer of knowledge would be pivotal to the project's success. Quote 3 shows that students recognized the need to do more than explain the technology to the community, they also had to frame their explanations in a culturally relevant way.

Working across languages

4. *I think it was harder for some of the students, some of the team, to connect and understand because they didn't know the language as well. I definitely saw that. There were quite a few people on our team that didn't really know Spanish. At least four or five of us. So I think that made it harder for people to connect and really understand the community's needs. -Guatemala Trip Participant*

5. *The ability to speak Spanish seems to be essential. I was able to communicate my thoughts and those of Tim directly to the construction workers, which allowed for a more open and effective dialogue. -Guatemala Trip Participant*

6. *A big one for me was speaking the language. I didn't actually get to teach until the very last day, which was not good; I should've jumped in sooner, but I don't know. I just kept trying to speak in Spanish instead of just sitting off in a corner by myself, and I'm definitely glad I did that because it gave me the confidence to actually try to speak to the community members on the last day. And I'm definitely glad that I tried to teach at all, because I think I would've been very disappointed if I came back not having even tried. -Guatemala Trip Participant*

All students in this study were required to communicate with non-English speakers in some capacity. In Guatemala students had varying levels of Spanish fluency and would communicate in Spanish to whatever extent was possible, or use other alternative forms of communication as seen in quote 5. At other locations, students used translators, facial expressions, hand motions, and body language to supplement communication when direct vocal communication was not an option. However speaking the local language was seen to allow for *better* communication as quote 4 indicates.

For the students who did have some Spanish speaking ability, it appeared to take them a few days of being on-site to begin to feel comfortable using it. By the end of the trip they all expressed increased confidence and language ability. Quote 6 expresses one student's experience overcoming their reservations about speaking a language they were not proficient in. Students who did not speak the native language recognized the gap it left in their ability to communicate appropriately, even if a translator was present.

Presentation skills

7. I don't think I've ever talked to large crowds ever in my life, and I didn't think I was going to be able to do this. So one thing I definitely took, because I talked to a bunch of people, is maybe I don't have that fear anymore. I feel more comfortable talking to larger crowds. -Guatemala Trip Participant

8. It's important to use a lot of different ways to explain the same thing. So, in the community we only had the written word; in the classroom, a lot of people only use PowerPoint, which drives me nuts because we were able to communicate an idea totally orally, to people who didn't even understand engineering, and they were able to have a vague idea of what was going on, or at least we think, because they were asking good questions about the system. -Cameroon Trip Participant

9. Today I attempted to teach a section of the presentation. It did not go very well as my Spanish is still not very good, but I learned to push my comfort zone. I am glad I attempted to teach part of it because I had felt like I was not really contributing to the education section previously without interacting with the community members. Guatemala Trip Participant

Students often needed to address groups of the community while on-site which gave them the opportunity to develop their presentation skills in a new environment. This helped one student overcome their fear of public speaking (quote 7). Students had to present in Spanish or to community members who did not speak English through the use of a translator. They noted the lack of the presentation tools such as PowerPoint and microphones developed their presentation skills even further by forcing problem solving and having to overcome presenting discomfort. Quote 8 shows that even without these tools, they were able to make an effective presentation. Students expressed that after having their comfort levels pushed on these trips they returned home more confident and comfortable speaking in front of people, or at least having tried, as seen in quote 9.

Establishment of trust and respect with community members

10. I think Pastor James is the invaluable guide, host, and connection between the community and us. And I think we couldn't do a lot of what we've done without him, or it would be a lot more difficult without him assisting us, guiding us through the project. -Cameroon Trip Participant

11. I wasn't expecting needing to go into quite as much detail about the water being

contaminated and why that's so important. I sort of knew that was going to happen. It's always so much more complicated, because some people use wells, some people they all have different ways that they're using their water. And pretty much everybody always says that they boil their water, but that's probably not true. And you always get answers, but I don't think they're always true. So, we definitely just keep emphasizing points over and over again. -Guatemala Trip Participant

Some students explicitly acknowledged the need to establish trust and respect with community members while others alluded to it, such as in quote 10. In order to work effectively in the community they needed to develop relationships that allowed for open communication, which often did not happen to the degree it needed. Students noticed behavior from community members that indicated a lack of trust or uncomfortability being honest with them. When working with community members on education outreach students had a hard time knowing whether or not the locals comprehended their instruction, evident in quote 11. In other situations students talked about the shift that occurred once they had the buy-in of certain individuals in the community. However, multiple times students noted that local community members seemed wary of the work being done by the travel team.

Documentation of data and information

12. The type of information we're getting can't even necessarily be written down or – I mean, it can't be written down. -Cameroon Trip Participant

Much of information acquired while on-site is stored in the memories of the student participants. This includes qualitative data, observations, and an understanding of the project environment. Also recognized was the the importance of documenting this knowledge in a way that it can be shared with other project members. Students who had returned from their travel expressed that they wished they had been able to document information better but often its not until returning, and sometimes months later, that they would realize what information they should have documented. However it poses a challenge because much of the information cannot be written down easily, as in quote 12.

Working across technical levels

13. I think it's kind of difficult to explain the concept of the filter to them when they haven't actually got the filter in front of them, because I don't know if they've seen it before. I don't think they've used it – and I think to respond to this, we've been focusing more on the basic hygiene and sanitation and why it's important to have clean water at this point. And then, hopefully as the project progresses, the social workers can continue to work with the community members to emphasize how the filters work and stuff like that. And just go over it again once they actually are able to see the filter. -Guatemala Trip Participant

14. I didn't think I was going to be able to get their attention when I was talking to them about hygiene and use of the filter. But they actually paid attention and I was really pleased with that. And they also stayed to ask questions, and I was really surprised. It was a good outcome. - Guatemala Trip Participant

Students often needed to discuss their design plans and the technology it included with people of varying levels of technical knowledge. For example, in Guatemala students were installing biosand filters in people's homes and needed to explain to the family how to use it and why it would be beneficial to them. Students had to gauge which aspects of this technology the families understood, and how to explain the parts they did not. This task was complex because they were working across language barriers, cultural barriers, and technical levels. They recruited two social workers to assist in this process but were still struggling with how best to approach this situation. This is discussed in quote 13 and 14. The need for communicating technical topics was also seen during the construction phase of the project.

Other related situations included presenting a pipe system design at a community meeting in Cameroon and explaining design decisions to community elders. Students recognized the challenge this task presented and created a presentation with as much visual demonstration as possible. Since having the community's support and understanding of the project is essential, students put a good deal of emphasis on addressing this communication challenge.

II. Technical Knowledge

You can learn in a textbook, but actually seeing it happen in real life, made a big difference. It definitely helped in system design later on. –Cameroon Trip Participant

But I think from my perspective, it definitely made me want to go back and re-read things and make sure I'm understanding and able to link concepts so that I can apply them out in the field. So, it's more intuitive and it's not like plugging into an equation and understanding. - Cameroon Trip Participant

You get the census data, you find out where the populations are, find out how much water they use. You find out how much water you bring. And then you design a distribution system such that each standpipe has a fair amount of pressure. And you use tanks to control for differences in elevation. I feel like I've learned a lot about fluid mechanics and designing rural water systems. - Cameroon Trip Participant

Engineering requirements have sometimes focused primarily on technical, engineering specific content. Students participating in international service-learning projects, such as EWB, have the valuable opportunity to apply their technical knowledge to a real world project. For this study technical knowledge was defined to include science, math, and engineering principles as well as more general problem solving techniques. Students applied this knowledge to engineering challenges such as designing a water distribution system and constructing biosand filters. They collected quantitative and qualitative data to inform their design decisions and often encountered obstacles, which required problem solving.

While working with limited data and limited resources students developed a better understanding of how engineering works in the real world. Many reported being able to make informed assumptions as a key characteristic of being an engineer. On the whole, there were many ways that being involved in this process helped students develop their identity as an engineer and

increased the confidence they had in their engineering abilities.

Within this category the following subcategories emerged from student reports: confidence in engineering ability, problem solving, further developed engineering identity, applied classroom learning, the acceptance of ambiguous information, and working with limited resources.

III. Personal Growth

There are all sorts of self-reflection that goes on when you're away from home, like when you're in a situation like that [being in a foreign environment]. And you realize what's important and what you want to be focusing on and what you should be focusing on. -Cameroon Trip Participants

You don't get that when you're in a classroom. It's when you're out there and you're talking to people that are suffering from water-borne illnesses and have children that are malnourished, that you really see the need. And I was able to really understand that more. -Guatemala Trip Participant

One of the most salient outcomes of participation in EWB that was observed was personal growth. Students openly recognized the impact their involvement in EWB had on their perspective of themselves, their career and the world. Traveling abroad required the project teams to work together to accomplish their goals even as they changed throughout the trip. The unpredictability of working in a new, foreign environment meant they had to be flexible and accommodating to unforeseen circumstances. This required each member to contribute, work together, and take on responsibilities that often involved doing new things and being in situations they were uncomfortable.

Being abroad presented personal challenges and often the more experienced project members helped others work through these challenges. Seeing cultures with living conditions so different from their own can be startling but ultimately students responded with an increased sense of responsibility to put their engineering expertise to meaningful work. Being abroad offered students an opportunity to reflect on themselves and their culture from a new perspective.

Within this category the following subcategories emerged from student reports: flexibility, teamwork, leadership, self-confidence, sense of responsibility, furthered engineering identity.

IV. Project Management

I think one of the things that I'm going to take away from this is the importance of formulating a good team. I think we did a really great job with that because we planned the education and the construction component and because we had these two components, so very little time was wasted and we managed to get a lot done really skillfully. So I think it was just really important to have everyone onboard and have everybody have a role and have something to do. - Guatemala Trip Participant

There was a lot of reevaluating and just adjusting our roles as we went along. Each night that

we were in the community, we met at the end of the day to just talk about what we did, the data we collected, anything. I guess the community interactions and stuff. And planning for the next day. So it was debriefing and then briefing for the next day. -Guatemala Trip Participant

Immersed in a real world project students must complete tasks on a tight time schedule while working with a small group of people in a new and often unpredictable environment. Thus, project management was seen as a primary component of student development while participating in international trips. Project management included any action that involved managing time, money, people and other resources appropriately. Students exhibited growth in their ability to efficiently organize the human resources of the team as well as to realize the importance of developing an information organization strategy.

Students also began to recognize the insider versus outsider perspective. Through various observations they noted how they were viewed as outsiders, which was a weighty position that came with responsibility and a reputation, but one that varied across demographics. Gaining an inside perspective into the community was seen as valuable and necessary for the project's success. Students with more travel experience were often at the forefront in devising management strategies, proving the value of experienced members.

Within this category the following subcategories emerged from student reports: scheduling activities appropriately, effective utilization of human resources, creation of an organization strategy, managing time, and insider versus outsider perspective.

V. Community-Based Development

I feel like the best way for me to assess their needs was to get to know them more and hear from them firsthand. -Cameroon Trip Participant

So, I've seen that we don't really know what we're doing ... participatory practices, the model the villager uses, the fact that you have to spend some time in the community to get an idea of how to do things properly, I think is obvious to me now. Communities are different enough from one another, that there is no blanket approach. You need to talk about things in terms of community participation and community management. -Guatemala Trip Participant

I would say the true measure of our project's success would be if we come back in 15 or 20 years, if the project is still working. The problem with so many of these design and development projects in developing countries is that the way that the systems are designed, they're just not designed to last. -Cameroon Trip Participant

EWB experiences abroad enable students to experience an alternative culture to their own and communicate with a different community in a way that is unequalled in traditional academia. Through these experiences students have various personal developments including within the vital category of community-based development. As made evident through this study, community-based development is defined as including the understanding the importance of recognizing the ownership the community innately has over the project and seeing the community as a primary project contributor. The ability to transfer knowledge to the community

was also identified as a significant component of implementing sustainable designs. Finally, students recognized the importance of having realistic expectations as an element of having community-based projects. This bottom-up approach to development was comprehended by students to be the foundation of sustainable and community-owned projects.

Within this category the following subcategories emerged from student reports: ability to transfer knowledge to community, understanding importance of community ownership, seeing community as a contributor, implementing sustainable design, and having realistic expectations.

VI. Intercultural Awareness

With EWB, there's so much more about understanding the people you're trying to help and the culture and the social factors and environmental factors. There's so much more to it than just the water treatment system you're trying to put. -Guatemala Trip Participant

Whenever you go into a new culture, you're going to be stretched. You're going to have to change. So being ready to experience the culture and interact with the people, building those relationships. That's how you're really going to have an impact, because when you're building that trust between your team and the people. And then, you know, working with them. Not working for them, but working together to solve whatever needs they have. - Guatemala Trip Participant

Developing an awareness of cultural differences is an apparent and major element of international EWB experiences. Through this study intercultural awareness was defined to include any discussion of the project or personal development through a cultural lens. While on-site for an EWB project, students are immersed within the local culture and have the opportunity to more accurately pursue a project by realizing the social, economic, and political climate of the community.

Students also demonstrated that while working in these foreign environments they also acquire an enhanced awareness of cultural differences. Many also expressed how this enhanced awareness consequently allowed them to work on their projects with respect to these cultural differences. Finally, students learned the importance of acquiring a community's trust, which creates an atmosphere of project sustainability. Overall, students on-site had the opportunity to increase their intercultural awareness through observation of the local community and reflection with project members.

Within this category the following subcategories emerged from student reports: ability to work within cultural differences, enhanced awareness of cultural differences, realization of social, economic, and political climate, and acquisition of community trust.

Discussion

I thought it was really nice being able to interact with the community members. It gave a perspective on the project that was difficult to get just working on it on our own in a classroom, although that is a very significant part of the project. It's just interesting to see how the two

parts, the engineering part and the personal part came together. - Guatemala Trip Participant

The findings of this study show the rich and diverse learning opportunities that can result from international engineering service learning experiences. Through experiential learning students are able to link academic skills to personal and interpersonal development and develop a deeper understanding of the holistic perspective required to successfully implement engineering projects. Five of the six categories presented here are not centered on engineering-specific skills, which are representative of those called for by the Engineer of 2020 and will help students excel in an increasingly competitive job market that expects interpersonal and project management skills.

However even within the single EWB chapter studied for this research there was a wide variance in student growth that resulted from their experiences. In general the reflection from senior project members were more complex and displayed a more holistic understanding of international engineering. Students could self-identify growth in certain areas but not in others. Through completing this research it became apparent students would benefit from a more structured, formal introduction to international engineering; one that would allow for development in each of the categories presented above. This paper identifies opportunities for student development but in practice students are not acquiring the full potential of development that is available from these opportunities. This is attributed at least partially to the lack of complete resources and guidance offered to students in EWB.

These results are meant to be a starting point, an invitation for further conversation about what development opportunities are being made available through international engineering service-learning. The areas identified in this paper represent the topics that emerged through the analysis of data collected for this study however the project team welcomes contributions from other experts and research. The method to this study provided a space for reflection from the students that then led to action. This action includes increased discussion as to how to better prepare students for development in each of the six categories as well as the development of learning objectives and modules to better instruct facilitators and academic professionals in these areas of development. This work can be greatly advanced by revisions of this framework or the presentation of alternative frameworks.

Conclusions

The goal for this study was to describe the effect that international service-learning has on student development. The unique perspective offered through international experiences provides a basis for students to more holistically understand cultural aspects of a project and understand community-based problem solving. By exposing students to the real world impact of their actions and decisions, students appeared to more fully understand concepts of their role as a global engineer and designing, implementing, and sustaining projects. Managing a project independent of a formal structure guides students to also grow personally and develop more matured management, communication, and applied technology skills. Analysis of data collected from students who participated in two Engineers Without Borders trips abroad informed the

creation of a preliminary framework that summarizes student development as a result of their involvement in these projects.

Using this framework as a guide, curricula, and materials can be developed to enhance the breadth of students' development. These findings may inform extracurricular material for Engineers Without Borders, learning modules for existing classes, and supplementary workshops. In the future this framework can be used as the basis for evaluating student development as a result of participation in international service-learning. A subsequent paper is being published by this research team outlining learning objectives in each of the six categories that will guide instructors developing curriculum in this field. Materials that offer students an introduction to the unique challenges presented by international engineering service projects should also be evaluated. Both students and professionals should contribute to this conversation to help identify what is and what can be learned through this type of development.

Finally, it is important to acknowledge that it is the academic communities responsibility to ensure that every international service-learning project is beneficial for all involved parties and not exploitative²² as warned by Vandersteen et al. International service-learning projects should not be done with a primary focus on student development but rather with sustainable, community-based development as the foundation.

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