

An Ethnographic Investigation into the Development of Engineers Without Borders USA Students During the Monitoring and Maintenance of a Potable Water System in Peru

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Abstract— This research category full paper is focused on the engineering co-curricular organization Engineers Without Borders (EWB) USA. This research investigates the travel experience of one group of EWB students at the University of Colorado, Boulder (CU) chapter from the Peru Team. The researcher was embedded as a participant observer on the EWB travel team joining the team on their trip to northern Peru where the team performed maintenance and monitoring tasks on a potable water system implemented the previous summer. The following research question was investigated: What are the impacts of the CU EWB travel experience on the development of CU engineering students? Several themes emerged from the analysis. The most prominent are: (1) Skill Development, throughout the experience the students were seen to gain skills not traditionally taught in an engineering classroom, (2) Passion, students involved with EWB commit many hours each week to the club and are passionate about what the club stands for, (3) Perspective, the students gained perspective on the world by traveling to a new place and experiencing a new culture, and (4) Career Interests, this trip made students more aware of the unique ways they can use their engineering skill sets.

Keywords—*international education; education in developing communities; service learning; project-based learning*

I. INTRODUCTION

Engineers without Borders (EWB) is an organization for undergraduate engineering students that focuses on international volunteer work. EWB students gain exposure to PBL and developing communities. This is valuable to undergraduate engineering education, due to its unique focus and volume of hands-on experiences. A large part of this organization is devoted to international travel to rural

communities to implement and monitor an engineering project. The students who are selected to go on these trips have the opportunity to experience a new culture and gain skills that they would not gain through traditional engineering education. This research category full paper investigates how an international experience with EWB impacts student development.

This study took place at the University of Colorado, Boulder. EWB was founded at the University of Colorado, Boulder in 2003 and the University currently has four developed teams that are working on projects across the globe. This study focused on the EWB Peru team. This team was chosen because it is the original team of EWB USA and has a strong history of taking two travel trips each academic year and successfully completing projects. The research question for this study is as follows: What are the impacts of the CU EWB travel experience on the development of CU engineering students?

Through out this paper Project-based Learning (PBL) will be used as the theoretical framework [1]. PBL involves groups of students working together to accomplish a larger project over an extended period of time. Throughout this process students learn skills both traditionally taught in engineering classrooms and skills not traditionally taught in engineering classrooms while working to complete their project. EWB fits well into the PBL framework. EWB involves very little formal learning and the majority of the learning occurs as the students work together in order to complete their project. Therefore PBL provides a good lens to view this data.

II. LITERATURE REVIEW

EWB is part of a larger group of PBL organizations. PBL has been praised for being extremely beneficial to students. One study found over the course of a twenty-year experience that PBL is the “most adequate educational methodology for the development of competence, liking teaching with the professional sphere” [1]. This shows the overall value that PBL can have for students. This paper will focus on PBL by looking into one organization that implements this framework, Engineers Without Borders.

Although EWB is a rapidly growing organization with about 300 [2] chapters across the United States, relatively little research has been done on the impact the club has on students. There has been some research done on the uniqueness of the students involved in the organization. Many students who were involved with EWB chose to study engineering because of their interest in EWB or EWB type work [3]. Additionally a study found that EWB students chose to study engineering due to an interest in helping others. That study also found that EWB students had wider interests compared to students not involved in EWB and had personality traits that were less common in engineers who were not involved with EWB [4]. This uniqueness of the students motivates research into what truly makes these students different from other engineering students. In another study the culture of a specific EWB team was analyzed. This study found that international travel was a large reason that EWB students choose to join EWB and a factor in the students staying motivated to continue their involvement in the club [5]. This was a motivator for the current research. If travel is a large factor motivating students to get involved and stay involved, then what do students gain from this international travel experience?

Research has been done on the type of students involved with EWB and the culture of the club; however, limited research has been done on the impact the club has on students. One paper discusses how much EWB teaches students with students gaining critical skills identified by ABET and exposure to humanitarian interests [6]. This idea is furthered in another paper that looks at gains from EWB-USA involvement. This paper discusses how EWB teaches students skills and helps to develop more diverse and well-rounded engineers [7]. Both of these papers show how valuable EWB is for student development but they focus on EWB as a whole. This research focuses on the specific benefits of the international travel experience associated with EWB. This could help to understand the source of skill development and student growth within EWB by narrowing the focus of the research.

III. METHODS

Ethnographic methods were used throughout the course of this study. Ethnography is the recording and analysis of a culture that is usually based on methods such as participant observation and interviewing [8]. In this study, the principal investigator (PI) was a participant observer on the EWB Peru team at the University of Colorado Boulder. The PI acted as a

standard EWB member interacting with the team as well as observing and interviewing the team.

A. Participants

The participants in this study were Engineers Without Borders (EWB) student members who were selected to travel. In order to be selected to travel, interested EWB students filled out an application and the members of the EWB leadership team who did not apply to travel screened the applications. Three students were selected to travel in the winter of 2017-2018; one of these students was the PI of this study. The other two students were the main participants of the study. Both of these students were male, junior standing in the Engineering College, and majoring in Mechanical Engineering. Both are involved and committed to EWB, participating in the club since they were freshmen. One of the students is the current project manager of the EWB Peru team and the other is the finance lead for the team. The largest difference between the two students is their travel history. One student had traveled with EWB in the past and had traveled a lot in his free time. Additionally this student's family is from South America and has exposure to that culture. The other student had not traveled outside the United States before this EWB trip.

B. Data Collection

The two main methods of data collection were observation and interviews. Observations were conducted throughout the study. The PI took notes whenever attending EWB meetings, interacting with the participants, and during the trip to Peru. Once all the observations were completed they were transferred to a computer so that the data could be analyzed with the interview data. The interviews were conducted with the participants before, during, and after the trip to Peru. The interviews before and after the trip were recorded on an audio recording device then transcribed. The interviews conducted in Peru were not recorded; instead the PI took notes during the interviews. These notes were also transferred to a computer. The PI received IRB approval before the start of the data collection.

C. Procedure

The PI was a participant observer during the course of the study. The PI was a fully participating member of EWB helping out with tasks as a normal EWB member as well as observing actions relevant to the study. There were three main stages to this study, before the trip, during the trip, and after the trip. The first stage of the study started when the PI was selected to join the travel team. Then the selected travel team members, with the help of the rest of the team began to prepare for the trip. They filled out all necessary paperwork required by EWB and planned out what was going to be accomplished during the trip. The PI also conducted pre-trip interviews. The pre-trip interviews focused on, why the students joined EWB, what they believed that they have gotten out of EWB so far, what their goals and expectations were for the trip to Peru, and what their long term goals were for after

graduation. All these questions were asked in an open-ended manner allowing the students to add additional information.

The trip to Peru was during winter break of the 2017-2018 academic year. The trip lasted two weeks and was to a rural community in northern Peru. The purpose of this trip was to monitor and do maintenance on the potable water system that was implemented during the previous trip, as well as to assess new communities for the next project. During the trip, the travel team worked on the water system and talked to community members about how the system was functioning. The team was able to make a modification in order to increase the flow the community was receiving from the system and increase the community satisfaction with the system. This was an a priori research project that was designed before the PI joined the travel team. Throughout the trip, the PI wrote down observations and conducted interviews with the other travel team members about how they believed the trip was impacting them. The interviews were mainly conducted over dinner at the end of the day when the team was reflecting on what they accomplished and what they were planning on doing the next day throughout the course of the two-week trip.

Once the travel team returned from Peru they all worked on documenting what occurred during the trip and transferring the knowledge gained to the other team members. The PI conducted post-trip interviews. The post-trip interviews were mainly focused around how they believed the trip impacted them. This included if the students thought they gained any skills or if the trip influenced any of their interests. Additional questions were asked about the benefit of experiencing a new culture.

D. Data Analysis

After all the data was gathered the PI analyzed it according to methods from Grounded Theory. Grounded Theory provides a data analysis framework that allows the researcher to develop codes out of the data and then analyze how the codes fit together in order to develop themes [9]. Following this model, the first step of analyzing the data was to transcribe it all into one file then sort it into codes. Once the data was organized into codes the researcher made a diagram to show how all the codes fit together as themes (Figure 1). Over the course of this project, the PI shared findings with members of EWB and the co-author for feedback on the analysis. This ensured that the data analysis was objective and not representing a single viewpoint.

IV. RESULTS

After analyzing the data four main themes emerged, Skill Development, Passion, Perspective, and Future Careers. The diagram below indicates how the themes fit together.

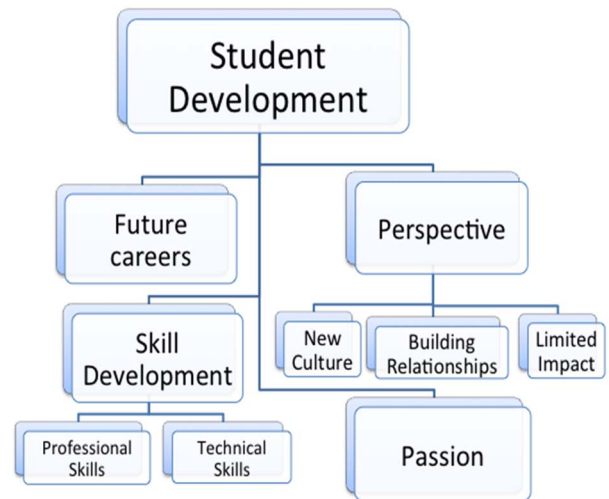


Figure 1: Organization of Themes

Student development appears at the top of the figure because of its relation to the research question: What are the impacts of the CU EWB travel experience on the development of CU engineering students? All of the identified themes lead to student development. Two themes have sub-themes that relate to them. Perspective has sub-themes of: (1) New Culture, (2) Building Relationships, and (3) Limited Impact. These three sub-themes lead to the students developing perspective. Skill Development also has sub-themes: (1) Professional Skills, and (2) Technical Skills. These themes and sub-themes are discussed further in the subsequent sections.

A. Skill Development

Students who have the opportunity to travel with EWB also have the opportunity to develop many skills. Through the design and the implementation of an engineering project, the students are able to develop many technical skills. Additionally, EWB is a completely student-run program and students are responsible for all aspects of the project. This means that the students make a budget, timeline, and source materials along with any other tasks associated with managing an engineering project. This gives the students the opportunity to learn professional skills that are not traditionally taught in most engineering classes.

The students who travel with EWB are responsible for building, maintaining or scoping out a project depending on the type of trip. The trip in winter of the 2017-2018 academic year was a monitoring and maintenance trip. This means that on this specific trip the students gained knowledge in taking water measurements, fixing components, and assessing the current state of the system. One student described the number of skills gained through EWB by stating "If I was never in this club I wouldn't know anything about Peru. I wouldn't know anything about water systems. I would know way less about hydraulics, about valves, about anything like that." These skills are often not taught in school but are still valuable technical knowledge. Through traditional engineering

education, students do not usually get the opportunity to gain hands-on experience like the students receive through traveling with EWB and working on a project internationally. One student even said, "Most of the practical knowledge I have learned is through EWB." Overall, this unique experience teaches students a broad range of technical skills that are not traditionally taught in school.

In addition to technical skills, EWB also allows students to gain professional skills. The students in EWB are responsible for all aspects of the project and not just the technical side. Through observation, the PI could see EWB students learning how to make a budget when planning for the trip, and learning how to be an effective leader when organizing a group of undergraduate students to meet a deadline. These are valuable skills but tend to be overlooked in traditional engineering education. One student commented, "A bunch of really smart people have got together and figured out exactly what classes I need to take in order to be a successful mechanical engineer. There's a lot of other things that might be good engineering practices and like things that you're probably expected at some point in life to learn. But I'm learning them nowhere as a college student. I am going to have that experience before I even go to the workforce because of EWB." This quote shows the breadth of knowledge you can gain from EWB and how valuable the students find it. These are skills that every member of EWB has the opportunity to gain but there are some professional skills that are mainly developed through travel with the club. One student commented, "I know how to do a technical drawing at this point, super well, I have done a ton of them, but actually like going to a community and interacting with your client you know and understanding their needs and understanding how what you build affects them and how what you built can be proved to improve their situation." This shows what professional skills can be gained through travel, for example, communication with the client.

Overall EWB gives students the opportunity to learn skills that are not traditionally seen in undergraduate engineering education courses but are incredibly valuable. These skills are technical such as learning in depth about how a rural water system works and professional skills such as learning about how to run a successful team and handle non-technical tasks such as budgeting. This skill development is one of the most valuable parts of being an EWB member.

B. Passion

EWB Students are very passionate about both the club and what it stands for. It is clear through observation just how passionate the students are about the club. This passion leads to many members becoming committed and devoting much of their free time to the club by spending hours each week in meetings and working on tasks for the project. This is significant as all of the members are full-time engineering students who have to be passionate in order to be willing to donate so much of their time to the club. Additionally, whenever a decision needs to be made the students spend hours debating the answer and running every scenario through

their minds. They want the best for the club and want the club to succeed.

During the trip to Peru in winter of 2017-2018, members who were back home in the United States spent hours on the phone with the travel team talking through all of the decisions that the travel team had to make. This shows how committed the members are even when they don't have the opportunity to travel themselves. To further this idea one student commented, "You know you're there right [Peru]. And that's because people fundraised and raised money and bought plane tickets and did a bunch of grunt work back in the States and there are 30 people who aren't going, who are just going on with their lives and kind of just waiting to hear back." This quote furthers the idea of commitment. Each travel trip, only a few students are able to go to Peru while many others worked to get those students there and are willing to do the work even if it is unlikely that they would be able to travel. Students become committed to EWB as a result of their passion for the club.

C. Perspective

What further differentiates EWB from other Engineering clubs is that the club is doing engineering projects in foreign countries. Students who travel with EWB have the opportunity to travel to an environment different from the environment they are usually in at school. The students have the opportunity to experience a culture, build relationships with locals, and see the impact of the project on the community. All of these experiences lead the students to gain a new perspective.

The EWB students that travel to Peru to work on their project interact with a new culture and see what life is like in a different part of the world. This can be an extremely valuable learning experience with one student commenting before the trip, "I think my personal goals are to actually just try and observe and not judge this, all the culture you know, and try and try and just take in as much information as I can on how people live elsewhere." This shows that the students recognize the value in this experience. Once in Peru another student stated, "I think it's really important to not be reminiscing on Boulder and talking about things that are going on in Boulder or just like going back to the hotel and like jumping on the Wi-Fi and just like checking Instagram and stuff you know like actually being there and maybe getting something out of it for yourself." This quote shows how important it is for students to really experience a new culture and not just work and then go back to the hotel when the work is done. Students have the opportunity to gain more out of this trip than just doing work for the club and the students recognize and value this. One student explained what they felt was the value of going in to a new culture that is different from your own by saying, "When you're the only white person in South America and everyone else is the ones staring at you then it gives you a bit more perspective on how people, where you're from, might feel like every day and then it makes you more like empathetic maybe." This quote shows that one of the values of being in a

new culture can be learning about what it is like to be an outsider and learning about how outsiders to your own culture may feel. This gives the students an experience and perspective that they could not gain if they did not travel to a foreign environment.

On EWB trips at this university, the students do not have a translator and are responsible for directly communicating with everyone in Peru on their own. This allows students to build relationships with the community members. Building relationships and talking with locals can be extremely valuable. It allows the students to gain an understanding of what it is like to live in rural Peru. One student explains talking to a child in the street, "that's the most important thing that happens on these trips. Looking at the boy in the eyes and hearing him say that his dream is to ride in an airplane, knowing that I'm going to sleep through one in a few days. He puts the world into perspective and you realize how unfair the hand you were dealt is and that it will take a whole lot more than a water system to do anything about it." This quote shows how impactful talking to the locals can be. It gave this student the realization that they were extremely fortunate, and that there was still a lot of work that needed to be done in the community, more than just a water system.

Getting to know the community members that the team is working with and observing others can have an impact on the student's viewpoints. One student commented, "Being there and seeing that your viewpoint shouldn't be that you want to help them help make their lives more like your life necessarily, but maybe it's more important that you realize by seeing them that you can be extremely happy and like have lived a virtuous and fulfilling life without those things, that maybe you should be more like them to move towards like a more sustainable consumption of resources." This further shows the impact that talking with and building relationships with local communities members can have on the students while traveling. The students learn from the community members and have the chance to see the value in the local perspective and that they could maybe alter their own lives in order to have an impact.

EWB is based on the principle that traveling to these rural communities for an engineering project improves the quality of life in the community. However, the only students who can truly see the impact of the project are the students who travel to Peru. Through observation and interviews, it was not clear what the exact impact of the project was on the community, "Maybe, in the end, we have succeeded to do what we set out to do but it took a very long time. It was like if you fail a class and then you take again and you pass the second time like I wouldn't call that a success. Which is what I would compare this experience too but it has been I think really educational." From this quote, one can see that the students aren't even sure how impactful or successful the project is. This struggling and questioning of success can be very beneficial for student development and perspective, "It's just the glorification of the white knights from Boulder are coming in and spending absurd amounts of money to like put together something that's

maybe not that phenomenal of a project. I still think we'll be doing good like it's important and people are thinking about this stuff and we're having discussions that wouldn't necessarily happen before." Through this quote it is clear that questioning the impact the team has on the community stimulates conversation that would not usually have happened. This also gives the students new perspective on development projects. The students begin to question projects in the future and work to ensure that the project is being done correctly. This type of questioning and perspective can only be done when the students truly understand all of the implications of the project, which is easier to understand after traveling to the community and observing first hand.

Through being in a new culture, building relationships with community members and seeing the impact of the engineering project the students who travel with EWB are able to gain perspective. They learn what it is like to live in an environment that is different than the environment they are usually in. This exposure can lead to the students thinking about what they have and what is important as well as thinking further about the impact of development projects on themselves and their future careers.

D. Future Careers

Many students who are involved with EWB are interested in careers that are focused on helping others. They want to be able to use their unique skills and interests that they have developed in the future. One student commented, "I really want to work in energy like in renewable energy because I think it's a way that similarly to EWB where I could use an engineering degree and expertise to make some sort of impact, to make society or people move towards a more sustainable existence." This shows that students who are involved with EWB want to have an impactful career similar to the way EWB impacts communities. The students do not want to settle for just an average job, "the example I would make is that I don't want to make toasters for the rest of my life." The students want to do something more and EWB is a factor in that. EWB exposes the students to experiences that they are not commonly exposed to in traditional engineering school, which influence their career interests. To further this idea one student stated, "I think EWB has helped me see that like I can do things that I find to be personally fulfilling and have some sort of larger implication to it." This student stated this after turning down a high paying job offer at a large oil and gas company. Turning down this job and stating that EWB has helped the student to see that they can have an impactful career truly shows how large of an impact being an EWB student can have on a student.

V. DISCUSSION

This ethnographic investigation into the impacts of PBL through international travel with EWB shows that the students who travel with EWB have a unique and valuable opportunity. The students gain technical and professional skills; develop a passion for what the club stands for; gain a new perspective through communicating with local community members,

experiencing a new culture, as well as seeing the impact the project has on the community; and gain interest in future careers similar to the work that EWB does.

A. Implications

There are several implications of this research. The main implication is that students become more aware of how fortunate they are by being involved with EWB. They learn how unique their developing skill set and interests are among other engineering students. This allows them to better market themselves to employers in the future.

The results of this study could also allow the club to recruit more effectively. They can point to the specific impacts of traveling with the club to students who may be interested in either joining EWB or to students that are already involved with EWB and considering traveling with EWB. This will allow the club to recruit more students as well as to recruit the most competitive students to have the best club possible.

This study also has a broader implication for engineering education. There are many organizations similar to EWB that focus on PBL. These organizations are also likely to have similar benefits to the students who are involved them. While this study is focused on EWB, the results can be used to look at other similar PBL organizations. There needs to be more research on PBL in general and this study demonstrates and adds to the benefits of PBL in engineering education.

B. Limitations

This research was only conducted at one university and only looked at one EWB team at the university. Therefore this research is limited to this specific EWB group. The team that was studied is the original team of EWB USA, very developed, and has a strong history of success. If this study was conducted at other university with other teams the results may vary. This study also only involved three students; therefore it did not have many perspectives. This could have shaped the results. Lastly, this study only looked at one EWB trip. It is not known if this is a typical EWB trip or if the student development observed on this trip is typical of all EWB trips.

Additionally with this research being viewed with a broader PBL lens, different project based organizations should also be studied. Then the results could be generalized to show the overall benefits of PBL and the individual strengths of each organization focused on PBL.

C. Future Research

There are many ways in which future research could. This research could be expanded to include all of the teams at the University of Colorado Boulder. This research could also be extended over a longer period of time. Additionally, this research could be extended to other universities. All of these extensions would allow for more in depth analysis and have broader results, helping to understand if all travel with EWB results in similar student development.

Another future direction for research would be to expand the study beyond EWB and look in to other PBL experiences in the engineering colleges such as design courses or organizations similar to EWB such as Bridges to Prosperity. This would broaden the research and capture a large number of engineering students with different PBL experiences.

D. Summary

The Engineers Without Borders Peru Team at the University of Colorado Boulder was studied in preparation, during, and after a monitoring and maintenance trip to rural northern Peru in order to discover how traveling with EWB impacts student development. The researcher was embedded as a participant observer on the travel team, helping with preparations for the team and joining the team in Peru. The PI conducted interviews before, during, and after the trip as well as observing the team throughout the duration of the research.

Through this ethnographic investigation, it was found that international travel with EWB is extremely valuable to participants. The main themes presented in this paper are: (1) Skill Development, throughout the experience the students were seen to gain skills not traditionally taught in an engineering classroom, (2) Passion, EWB students are very passionate about helping others, (3) Perspective, the students gained perspective on the world by traveling to a new place and experiencing a new culture, and (4) Career Interests, this trip made students more aware of the unique ways they can use their engineering skill sets. Overall, International travel with EWB is extremely valuable for the students and unique among engineering education opportunities.

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