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Developing Global Engineering Competency Through Participation in "Engineers Without Borders"

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Abstract

With a growing need for globally competent engineers, global engineering educational experiences, such as *Engineers Without Borders* (EWB), have become an important potential avenue for teaching students global engineering competencies. The purpose of this qualitative case study was to better understand engineering students' learning experiences in a EWB project, looking specifically at how students participating on the project exhibit attributes of global engineering competencies. The case study investigates an EWB project with the mission of designing and implementing a solar-powered electricity system for a school in Uganda. We found that students do exhibit attributes of global engineering competencies, although attributes regarding engineering cultures and ethics were exhibited more strongly than attributes regarding global regulations and standards. We discuss implications of these findings for educational practice and future research.

Introduction

Providing engineering students opportunities to develop global competencies has become a pressing necessity for engineering programs given the highly global nature of engineering work that requires the ability to work productively with other cultures. Study abroad programs, virtual global courses, and courses and modules focused on engineering for a global society, are all pedagogical approaches to improving engineering students' global competencies. Although these formal education approaches can be highly effective, they are not always accessible to a wide population of students and largely engage students for only a single and short portion of students' academic experiences.[1] Increasingly, extracurricular activities, such as EWB, have emerged as another an alternative that offer students an opportunity to be immersed with global engineering challenges throughout their undergraduate careers.[2]

The purpose of this study was to better understand engineering students' learning experiences in an extracurricular activity focused on global engineering issues, specifically how participation in EWB influences the ways students exhibit global competency attributes. Understanding participating students' perspectives can help begin to identify the affordances and/or barriers of EWB that most influence students' development as global engineers. Research questions that guided our study were:

> **RQ1:** How do students describe their learning experiences with EWB?
> **RQ2:** What are the affordances and/or barriers of participating with EWB that most influence students' global competency development?

Our goal in exploring these particular research questions is to shed light how students participating in EWB exhibit global competency development. Specifically, we strive to understand the student perspective of the EWB educational experience with the goal of having a more informed understanding of how such an experience might be assessed in the future as an accepted educational avenue for exposing students to authentic global engineering projects.

Global Competencies in Engineering Education

In the last 15 years, Engineering programs in the U.S. have been working towards improving engineering education, recognizing the necessity to enhance and modernize engineering education to better meet the demands of future engineering challenges.[3] Global competency is one of the important skills that has been identified by the engineering education community as essential and expected of all engineering graduates. Various curricular and non-curricular approaches have been implemented in engineering programs in the U.S. for the specific need of teaching and exposing engineering students to global engineering challenges.[1,4]

An important question to consider when developing, implementing, or evaluating any educational approach to teaching global competence is what it means to be a globally competent engineer. Having an inclusive, operational, and explicit definition for global competence that is agreed upon in the engineering education literature appears to be elusive, however there does appear to be an agreement for what the engineering education community has identified as general attributes of "global engineering competency". "Global engineering competency" refers to "those attributes uniquely or especially relevant for cross-national/cultural practice" (p. 660).[5] The attributes global engineering competency refers to include engineering ethics, engineering cultures, and regulations and standards. Table 1 lists how these attributes are further characterized in the literature.

Table 1. Attributes of Global Engineering Competency[5]

Attributes of Global Engineering Competency	**Definition**
Engineering Ethics	Capability of handling situations with ethical issues due to national/cultural differences
Engineering Cultures	Capability of understanding how engineering challenges and solutions are situated within national/cultural contexts
Regulations and Standards	Capability of understanding the national/cultural regulatory aspects influence engineering solution applications

The literature has also identified essential elements needed to produce global competency, specifically "coursework in international studies, second language proficiency and international experience" (p. 121).[4] Similarly, the literature has also identified specific learning outcomes to account for when examining global competency, such as: demonstrating "knowledge" of cultural differences in engineering work; demonstrating an "ability" to perform engineering work in global settings; having a "predisposition" to work effectively and respectfully with people of different cultural backgrounds; having an awareness of political/societal issues in global contexts; having an understanding of the globalization of engineering education; and having an understanding of international business, market, economy.[4,6,7]

Although these attributes and proposed learning outcomes are not concrete definitions of a globally competent engineer, they do provide insight into what is expected of globally competent engineers. A possible hindrance to explicitly stating a single definition and concise expected outcomes of educational global experiences for engineers might be the wide variety of strategies used to teach and expose engineering students to global engineering. What students experience in a course regarding engineering work with respect to international business and economy is not likely to be equivalent to what students experience in a study abroad program, or while working and traveling abroad for a global service learning project.[1] Such a complex skill is not likely to be fully captured by a single educational intervention. Engineering education research thus far has focused on the need for globally competent engineers and defining what that means, but research that investigates the possible educational avenues that might be used to accomplish these educational missions has been limited. This study aims to investigate students' learning experiences in a global service learning project, as a preliminary investigation into one possible educational avenue for teaching global engineering competency. More deeply understanding experiences of students working on global service projects can better inform engineering educators of the specific outcomes that might be expected of similar educational experiences.

Research Study

This study is a qualitative case-study of students working on a global service learning project at a large research intensive state institution in the U.S. We observed a team of 8 students working on a EWB sponsored project. We chose a EWB team because it is one of the more common and recognizable global service learning experiences available to engineering students in the U.S. The following sections will describe the research study design in more detail.

Research Site and Participants

This particular team of EWB students was working towards developing, implementing, and assessing a solar-powered electrical system for a school located in a remote area in Uganda. From here on, the team will be referred to as EWB-U. The study site and experience were non-mandatory for students to receive their degrees, and students self-selected to participate on the team. The team consisted of 8 students (3 senior/fifth-year students, 2 juniors, 1 sophomore, 2 freshmen), from various engineering majors including mechanical engineering, civil engineering, electrical engineering, and chemical engineering. The team was predominantly male, with only 2 female participants. The team was almost entirely student-run. The only non-student participant was an industry mentor who was a practicing electrical engineer from a local engineering company. The industry mentor would occasionally advise students on the electrical system design (via email, phone, or in-person meetings), and the industry mentor would also travel with the student team during the 3-week summer implementation/assessment trip to Uganda.

Methodology

This research employed a case study approach to examine the dynamics present within a service learning project team.[8] Qualitative methods were used to understand students' experiences of students regularly and actively participating in a EWB project. The primary purpose of this investigation was to understand students' experiences, rather than to measure learning outcomes, justifying a qualitative approach.[9,10]

A researcher with no affiliation with the EWB project conducted naturalistic observations, interview, and focus group discussions. Semi-structured interviews and focus groups were conducted with participating students. The eight student members participated in a one-hour focus group discussion, and the team leader participated in a 90-minute interview. The focus group protocol focused on students' decision to join the EWB, their experiences with EWB, their goals with EWB and professionally, and their general experiences and perceptions of their education as engineering students. The student leader was asked a couple of questions regarding their experience as a student leader, as well as questions regarding their educational and professional trajectory.

To supplement the interview and focus group data, observations of student meetings were conducted, detailed field notes were documented for all observations, and archival data was collected. The observer attempted to remain as an external observer as much as possible, with minimal interactions with participants. To ensure trustworthiness of observations and analysis, triangulation, reflexivity external audits, and peer examination were used.[11] Observation protocol focused primarily on conversation topics, student behavior, student actions, student interactions, and student-mentor interactions. Also, observation data from the research site somewhat informed the focus group protocol. For example, if a focus group participant discussed a particular event that the researchers had also observed, the focus group facilitator would bring up that observed instance as a clarifying example. EWB team observations included observations of typical team meetings. In addition to the observations, archival data from the research site was collected to further supplement the interview data. Specifically the team's website, team photos, and documents or reports written by the team were collected. This information was used to better familiarize and contextualize the type of environment that the team creates for students.

Data analysis was primarily guided by the global engineering competencies described earlier in Table 1. These attributes were used as constructs to guide the coding and analysis of the focus group and interview. More specifically, instances where students made a statement reflective of a global competency attribute ('engineering ethics', 'engineering cultures', or 'regulations and standards') were coded as such, and each instance was further analyzed to identify how the attribute was exhibited. It should be noted that this study is limited by being an examination of a single case. However, the scope of this study is that of a preliminary study, with the aim of beginning to characterize student experiences and identifying the potential affordances and barriers of similar global service learning projects. The results of this preliminary study will be used to inform a larger study examining a variety of learning environments that have missions to enhance engineering students' global competency. It should also be noted that this study is an IRB-approved study. For the sake of protecting the study participants' identities, no personal identifiers will be used; names used to identify quotes from the data are pseudonyms. Quotes presented in the findings have been minimally edited to maintain grammatical clarity.

Research Findings

Recruitment issues, perceived time commitment, and gaps in knowledge transfer between outgoing and incoming student members were salient barriers to the sustainable success of EWB. However, once students commit to a EWB project, EWB serves as an example of how engineering students can be exposed to educational yet authentic global engineering experiences in ways that are meaningful and impactful to each student. Consistently active student members exhibited an awareness and capacity to work productively within the boundaries of an unfamiliar cultural context, successfully communicating and achieving the defined goals and tasks, as well as exhibiting a capacity to work across disciplinary and cultural boundaries to achieve a common goal. The following sections will discuss the findings with respect to the specific global engineering competency attributes exhibited by the students, as well as the affordances of participating in EWB and the barriers to participating in EWB.

Engineering Ethics

Students from the EWB-U team exhibited some attributes of engineering ethics (i.e., capability of handling situations with ethical issues due to national/cultural differences), particularly within the domain of recognizing a "[d]epth of concern for people in all parts of the world…moral responsibility to improve conditions and take action in diverse engineering settings" (p. 3).[12] Having an innate desire to help others around the world accounts for much of the students' motivation to participate in EWB-U. Even more specifically, the participating students often sited wanting to apply their engineering skills in knowledge in ways that could help improve the condition of the world, such as the following statement by Frank.

> [Frank]: "I wanted to help people and volunteer my time, and help out. I'm an electrical engineering student, so this very much lines up with what I want to do, cause I want to do power and alternate energies."

Working towards designing, developing, and assessing a solar-powered electrical system for a school in a remote location of Uganda, EWB-U students were able to feel as if they were making a difference on two fronts – sustainable energy systems and community service. Many of the students also stated that they initially considered engineering to be a relatively narrow profession. However, once they showed up to EWB interest meetings (held at the beginning of each academic term), they stated how that was when they realized that engineering can be applied in many diverse ways. Martin and Carmen, for example, both acknowledged that it is their goal to find engineering jobs where the priority is to make a difference rather than make money.

> [Martin]: "There's a lot stuff you can make, and you can get a job and have a professional career and all that. But there's a lot of other things you can do with an engineering degree [than just

> making money]… But I think using it, you know, for something like this is much more up my alley."
> [Carmen]: "I [feel] like it [is] my responsibility to serve others, and try to make the world a better place."

Overall, the students are very driven by a perceived necessity to do the work that they do for the Ugandan community.

> [Carmen]: "[I] [d]efinitely want to see the project move forward and continue. I've dealt with other projects that come to a stand still for whatever reason…When you have a connection, when you've traveled, you want this to happen. You want people to have electricity…if you don't do it, then no one else will."

However, they also recognize that they are limited in their ability to contribute given that they are engineering students, with limited experience, time, and resources to contribute. The students recognize that although they spend the academic year designing and preparing for the implementation trip, they are only on-site for about 3-weeks, which limits the amount of long-term impact they can have on the community. Even so, the students do not let the realities of the situation deter their willingness and motivation to pursue the engineering challenge, as demonstrated by Craig's statement below.

> [Craig]: "You know, you're not gonna save the world or anything like that. That doesn't mean you have to sit on your hands and not do anything."

Engineering Cultures

Students also exhibited attributes of understanding engineering cultures (i.e., capability of understanding how engineering challenges and solutions are situated within national/cultural contexts), with this particular attribute seemingly being the most strongly exhibited out of the three (i.e. engineering ethics, engineering cultures, and regulations and standards). The students demonstrated that they were very much aware of the constraints they were working under by keeping in mind the cultural context in which they were working. For instance, Craig, who had worked with EWB-U for nearly 3 years, noted how his first summer trip was focused on designing and implementing the system. The second year was focused on design changes, implementation, and initial assessment of the system. The upcoming trip was focused on implementing changes based on the 2nd year's assessment, and conducting further assessment of the system. When asked to give an example of how the design might change year to year, Craig stated:

> [Craig]: "I think every year the new system kind of reflects the results of the last monitoring. At [the school] we have the two-inverter system that we could switch back and forth, and that was definitely a new concept that we used. It should work a lot better **for their specific needs**."

Craig's example demonstrates how the students maintain an awareness of the specific needs of the community they are serving. Similarly, when describing to the newest team members the decision-making process for deciding where and how to place the solar-powered electrical systems, the students who had traveled earlier described that they wanted to look for places with enough sunlight, but away from major roads, because “if [community members] don’t know they’re there, they can’t steal them”. This student interaction, which was observed during a team meeting, demonstrates how the EWB-U members are well aware of the realities of the cultural context of their project, and the students’ recognition of the design constraints with which they are working. Carmen provides another example of how the students demonstrated an understanding of how implications of cultural differences might inform engineering solutions when she stated the following:

> [Carmen]: “[W]hen I traveled I learned a lot more about what actually works in sustainable development, and what you *can* do, and I saw a lot of different problems. Like, I know now I’m more interested in incinerating trash, because you see huge problems in Uganda. There’s no trash pick-up, because you know all the money is focused on the roads and just keeping up basic infrastructure. But now that they’re finding ways to use trash to create energy, that’s what I’m really interested in, and hopefully one day I think there should be ways, incentives to not only clean up an area, but to use that to produce renewable energy”

Carmen also exhibited an understanding of the importance of needing to be fully educated about the general cultural context with which the students are working, in order to work productively, effectively, and respectfully.

> [Carmen]: “EWB made me realize that I wanted to be more than just an engineer. I picked up another major – sociology- because I was talking to everyone, and I realized - like I mean I want to do engineering, I want to help in that way - but I also realized that **I need to learn a lot about other people and culture because you know it’s a completely different life over there**. And you don’t even really understand - like things we do in the U.S., like standing up when you’re eating is considered rude over there, and it’s something we would never consider over here.”

Other students recognized the value of the human relationships they make while participating abroad in EWB-U, understanding that those relationships might have a more lasting effect than the electrical systems that they design and implement.

> [Will]: “The first trip I went [on], I was very focused on being productive, and I just wanted to work all the time. But one of the things that I kind of learned from [industry mentor], when I went over there the second time, is your relationships that you build with people, they will last longer than the equipment that you’ll bring. And that made a lot of sense to me looking back on the first trip.”

Regulations and Standards

The remaining global competency attribute, regulations and standards (i.e., capability of understanding the national/cultural regulatory aspects influence engineering solution applications), was the attribute the students exhibited the least. The closest demonstration of this attribute was during an observation of student discussions during a team meeting. During this meeting, the team leader was discussing that a new task added to their upcoming trip to Uganda, in addition to assessing the current electrical system, was to build a safe welding laboratory for the school EWB-U was serving. In addition to building the facility, the students, along with their industry mentor, were also going to host a workshop on safe welding for the students of the school EWB-U was serving.

The students' reasoning for building the welding facility and hosting a safe welding workshop was because of past observations, made by students who had traveled, of how unsafely welding work was currently done in this particular Ugandan community. Considering that their particular engineering solution involved quite a bit of welding work, finding welders who could work safely and with the appropriate equipment was very difficult for the EWB-U team. The EWB-U students recognized that regulations and standards regarding appropriate work conditions and procedures are very different in Uganda, as compared to the U.S., however they felt obligated to spread the awareness of proper welding techniques for the young Ugandan students that the EWB-U team was serving.

Affordances of Participation & Barriers to Participation

As illustrated in the previous section, the engineering students participating in EWB-U exhibited attributes of global engineering competency. Certain affordances offered by participating in EWB-U, that other educational experiences might not provide, might account for students exhibiting global competency attributes. For instance, the students frequently mentioned how much more meaningful participating in EWB-U has been, as compared to what they typically get out of a curricular course.

> [Shawn]: "I learn a lot more going on trips than I do in my classes and like doing all this work, you know like you're working for a purpose, you're doing something real."

> [Carmen]: "EWB has that cultural component that you're not going to get you know sitting here and doing this design work and you're not going to get uh you know in a classroom."

> [Craig]: "It forces you to meet people under the best possible circumstances. Which is nice."

> [Will]: "Here it's actual hands on…you gotta assess it, you analyze it, and then you implement it all the way through, like beginning to end. That's the best experience I'll probably get in my entire time here [in college]; a volunteer thing."

The students frequently indicated how the work they put into EWB-U had a greater meaning than just "getting a grade". This greater meaning fed the students' drive to be engaged in an engineering challenge that required them to understand and develop global competency attributes in order to succeed. Through EWB-U, the students were able to experience engineering working that benefited a community in need, all while experiencing engineering work in an authentic setting (i.e., financial constraints, timelines, client needs, demand for innovative solutions). Additionally, EWB-U provides students with an opportunity to be self-directed learners, by requiring them to manage their own schedules and tasks.

> [Will]: "It's kind of student-run, and that makes it fun as well. You just make your own schedule and everything like that. It's a good experience that way too."

> [Carmen]: "It's non-threatening because everyone is around the same age, doing the same classes…I get intimated talking to professors, but I feel like I can talk to all the people in our group, and I can talk to our mentor pretty easily."

Despite the positive affordances, there are substantial barriers to participation that prevent students from taking full advantage of the opportunities EWB, and similar extracurricular activities, have to offer. One barrier pointed out by the students was the general lack of student awareness that EWB exists, making recruitment for the team difficult.

> [Shawn]: "People don't really know about EWB. It's 10 years old, everyone assumes that it's Doctors Without Borders, and people on campus don't really have good ways of finding out about it unless they're part of some [email] listserv, or they happen to see some signs somewhere"

An even larger barrier that students identified was having the time to participate in EWB while completing rigorous engineering coursework. Although EWB offers a valuable educational experience, specifically with regard to global competency, students' academic achievement (i.e. grades and GPA) remains to be the priority.

> [Carmen]: "Sometimes it's hard balancing school and [EWB]. You know, for some people, it's more important to do well in their classes, where I guess, I kind of sometimes am one of those people who's like 'well… [forget about] differential equations, I don't really care anyways'. You know, I can do matrices, so I'm just going to work on [EWB project] instead. [S]ometimes balance is difficult. Staying interested [in EWB] with a heavy course load is hard to do"

> [Craig]: "You only have so many hours of productive work in a week, and when you try to throw that on top of coursework - there were definitely assignments that I didn't do while I was finishing paperwork for EWB. So that was uh, I don't know. I learned a lot from doing [the paperwork]."

Students participating in EWB-U do not receive any academic credit or acknowledgement for their participation, or for their success in implementing a functioning solar-powered electrical system for the community in need. While the students involved in this study appeared to prioritize the EWB-U project above their coursework, the students did acknowledge that, at the very least, they needed to be able to pass their classes in order to graduate. This time demand can be a significant barrier to participation for students focused on maintaining a high GPA, such as students needing to meet scholarship requirements.

Discussion

The purpose of this study was to investigate students' learning experiences with EWB, specifically identifying how students participating in EWB might exhibit global competency development. Overall, in our research study we found evidence that students who participated in this particular EWB exhibited attributes of global engineering competency, although the students exhibited certain attributes more than others. Specifically, and understanding of 'engineering cultures' was strongly exhibited by the students, whereas only some demonstration of understanding 'engineering ethics' and 'regulations and standards' was observed of the students.

While students showed a strong "moral responsibility to improve conditions and take action in diverse engineering settings" (p. 11)[12], the students never explicitly discussed the possibility of ethical issues that might arise from cultural differences[13], neither during focus group discussions nor during observations of team meetings. The students also did not discuss much in terms of the impact that international or global differences in workplace practices, regulations, or standards might have on their project.

The ways students exhibited global competency attributes could be due the nature of this particular engineering context, where students are voluntarily serving a community, rather than developing a product to be sold to a global market. Regulations and standards of the served community are important elements for students to consider, particularly regarding how cultural differences relate to product design, implementation, and use. However, having an understanding of intellectual property, business practices, and the international labor market is less relevant to students working on a global service learning project such as EWB-U. These elements of regulations and standards would be more relevant to students experiencing an engineering challenge sponsored by a global corporation. The students are primarily driven to learn enough to successfully meet the needs of the community they are serving. One possible strategy for ensuring students are exposed to all global competency attributes would be to offer students "skill sessions"[14], or similar workshop-style meetings, that could attempt to scaffold students' educational experience with global engineering work.

The EWB-U students did appear to have a strong understanding of the cultural implications and contexts of the community they were serving, which has been noted by previous similar studies[15,16]. Even more promising, the students demonstrated a willingness and desire to learn more about various international cultures, and the cultural implications to engineering, either through additional coursework or practical experiences. This could be attributed to the affordance of the EWB experience of exposing students to long-term authentic global engineering challenges. There are few research studies regarding the attributes of global engineering competency exhibited by engineering students participating in global service learning projects[5], so this study has contributed an examination of if and how attributes of global engineering competencies are exhibited by EWB student members. This study also identified a unique affordance that EWB provided students, which is to provide students with an authentic global engineering experience. Beyond needing engineers who can understand or be aware of global engineering competencies, engineers need to be able to apply and effectively work beyond global boundaries[17], which EWB offers students the experience to practice.

These findings appear to imply that global service learning projects, such as EWB team described by the study, are effective educational avenues for students to learn and be exposed to global engineering competencies. However, there are certain limitations of this study that should be considered. First, this study is a preliminary examination of the educational possibilities that global service learning projects might offer. More in-depth analyses of other similar global service learning projects, with additional cases available for comparison, can provide an examination that is wider in breadth regarding the affordances and barriers of global service learning projects. Second, the aim of this study was not to make claims of measured learning outcomes of students participating in global service learning projects, but rather was to describe and characterize the experiences of students participating in a global service learning project.

Previous studies have presented useful survey and assessment constructs regarding global competency[1,16,18], and the findings of this study do further inform future research regarding measured learning outcomes by providing specific constructs that can be expected of global service learning project students:

- In terms of engineering ethics, future studies aimed at measuring learning outcomes should focus on measuring students' awareness and understanding ethical issues pertaining to their project's cultural context. Engineering educators, industry professionals, or student leaders who mentor or lead related global service learning projects should consider having team members explicitly discuss and plan for potential ethical issues pertaining to the project's cultural context.

- With regard to engineering cultures, future studies aimed at measuring learning outcomes should focus on measuring students' awareness and understanding of cultural norms, and the implications these cultural contexts have on engineering solutions and applications. In terms of practice, team members should be tasked with learning and discussing expected cultural norms, as well as discussing and designing engineering solutions while considering the constraints and implications of the cultural context.

- Considering regulations and standards, future research aimed at measuring learning outcomes should focus on measuring students' understanding of the regulations and standards of the country and/or community they are visiting, as well as an understanding of how these regulations and standards might influence their project design and implementation. In practice, team members should be tasked with studying the relevant regulations and standards that would impact their engineering solution/application, as well as discuss possible approaches to handling unexpected situations regarding workplace practices or other economic/market issues.

The findings of this study indicate that expected learning outcomes of global educational experiences should be tailored to the mission of the educational experience. This recommendation has been previously expressed by other education literature on the alignment of curricular educational experiences and expected learning outcomes[18,20], and we believe it also applies in this non-curricular educational experience. Courses on engineering cultures or globalization of engineering cannot be expected to give students the same educational experience as global service learning projects, just as multi-national online courses will not have an identical educational influence as study abroad programs. While all global educational experiences share the characteristic of being avenues for teaching global competencies, they are all unique in terms of the specific global competency attributes that they can develop in students. Engineering educators, researchers, administrators, accreditors, and employers should account for these differences among global educational experiences when considering the global engineering competencies of engineering graduates. Future research should examine the comparison of various common global educational experiences with respect to their specific expected learning outcomes. With a greater understanding of how various global educational experience impact students' learning, opportunities such as EWB can be more strongly considered a *co*-curricular experience (i.e., an experience geared towards enhancing relevant curricular demands), rather than an *extra*-curricular experience (i.e. additional experiences outside of curricular demands) within the grander context of engineering education.

Conclusion

Responding to the increased demand for engineers with global competencies, the engineering education community has implemented a variety of global educational interventions, such as courses focused on engineering cultures, global virtual classrooms, and global service learning projects. This study aimed to characterize the educational experiences of engineering students participating in a EWB project by using an accepted definition of global engineering competencies to guide the study analysis. This study also identified the affordances of participating and the barriers to participating in global service learning projects, as described by participating student members.

Students participating in EWB-U exhibited all attributes of global engineering competencies (engineering ethics, engineering cultures, and regulations and standards), however, regulations and standards was the weakest attribute exhibited by the students. We believe this was the weakest attribute demonstrated by students because of the inherent mission of EWB, which is more driven by global service needs rather than international corporate needs. Even so, we have detailed recommendations for how similar global service learning projects might enhance student members' development of global engineering competencies. Affordances of participating in EWB, as described by the students, includes having authentic and meaningful global engineering experiences, as well as providing an educational environment for students to behave as self-directed learners. The barriers to participation, however, are primarily the time constraints typical of engineering students working through rigorous engineering coursework, as well as a general lack of student awareness of EWB, which complicates the recruitment of new student members.

This study implies that global service learning projects are an effective educational approach to teaching engineering students global competencies. Research on specific educational experiences that influence students' development of global engineering competencies is relatively limited, so it is our hope that this study adds to this body of literature by providing a model for using existing literature on defined global engineering competencies to examine the role of various global engineering educational experiences. Being a preliminary exploratory study, we have described how our findings might inform future studies of other global service learning experiences, as well as other curricular and non-curricular educational experiences geared towards developing students' global engineering competencies.

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