First-Year Engineering Student Reflections on Service Learning: The EWB Australia Challenge

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***Abstract*—This work in progress paper presents preliminary results from a broader study exploring student reflections on the Engineers Without Borders Australia Challenge during its pilot year at a Midwestern technical institution. Students were surveyed using Likert scale questions, as well as short response open-ended reflection questions. Convergent coding methods were used to identify emerging themes within student reflections. Student reflections of the Challenge were overwhelmingly positive. Students also reflected on their perception of the role of an engineer in society, citing the growing importance of empathy and global preparedness, and the need for a broad skill set that prepares the engineer to work in multidisciplinary teams and environments.**

***Index Terms*—Service Learning and First Year Engineering.**

I. Introduction

Service learning, included under the umbrella of experiential education, has become an increasingly popular educational tool in engineering curricula [1-2]. This style of learning introduces students to course concepts through service projects within the community, and leads to the development of new skills through collaboration. Participation in these opportunities has been linked to enhanced student personal outcomes, including development associated with increased self efficacy and personal engineering identity. Additionally, service learning opportunities have been connected to enhance social outcomes in students, including a development of racial and cultural understanding [3]. However, service learning projects can be difficult and time consuming for instructors to organize, and project development may rely on the personal contacts of the instructors. Thus, partnering with existing humanitarian aid organizations, such as Engineers Without Borders (EWB), can provide students with the developmental benefits of service learning experiences, while at the same time leveraging the contacts and work of these organizations [4].

II. Background

Since 2007, Engineers Without Borders Australia (EWB AU) has invited first-year engineering (FYE) students to participate in their annual Challenge, which engages students in real-world, community-based design projects to improve the lives of those living in poverty. Community partners work with EWB AU staff to develop a design brief, identifying potential projects and priorities in their community. The 2019 Challenge, completed by our students during the spring of 2020, focused primarily on water aid projects in communities throughout Suco Holarua, located in the Manufahi District of Timor Leste [4].

At Michigan Technological University (MTU), all engineering students take a common set of two introductory engineering courses. The second course in this two part series includes a semester-long engineering design project, approached using a Design Thinking (DT) conceptual framework [5]. In order to achieve this, students are introduced to the concepts of Design Thinking through the course learning content and utilize the framework in their designs for the EWB AU Challenge. These FYE courses are designed to be discovery-based and place emphasis on peer learning and teamwork [6], sharing values with those of the EWB community and aligning with the goals of the EWB AU Challenge [4].

Prior to the implementation of the Challenge at MTU, only one institution in the U.S. had participated in the EWB AU Challenge. The initial participant, Colorado State University (CSU), developed a post-course survey containing Likert scale questions regarding student reactions to the Challenge. Analysis of the survey responses from participating CSU students overwhelmingly indicated that the EWB AU Challenge had a positive influence on the development of personal skills (working with teams, exchanging ideas with others, project management, and meeting deadlines). Additionally, CSU student responses indicated a positive influence of the project on their understanding of the role of an engineer in society, the role of an engineer in a project, and the importance of consideration of culture in making engineering decisions [7]. While the results from the CSU survey provide some insight into the benefits and learning outcomes of the EWB AU Challenge, responses were limited to Likert scale answers. The CSU study does not explain *how* participation in the Challenge specifically develops or alters student understanding of the role of an engineer. This work aims to provide additional context and insight into the findings of Siller and coauthors, through exploratory research investigating whether participation in the Challenge changes students' views on the role(s) of an engineer.

III. Methods

At the conclusion of the spring 2020 semester, 69 of 72 students enrolled in the EWB section of their second semester engineering course at MTU completed a survey (95.8% response rate). Prior to administration, the survey was reviewed

with the Director of Human Research Protection Programs and deemed exempt from full IRB review. Informed consent was acquired from survey participants. Students were awarded 10 extra credit points for participating in the survey. Demographic data was not collected as a part of this study. In the 2019/2020 school year, the College of Engineering at MTU was 0.11% American Indian/Alaskan Native, 0.68% African American, 1.5% Asian/Asian American, 1.8% Hispanic/Hispanic American, 79.3% White, 12% international students, 3.9% multiracial, and 1.5% unknown [8]. Of the undergraduate engineering degrees awarded in 2018, 24.6% were earned by women [9]. As the first year engineering program encompasses all engineering majors, these demographics could be considered to approximate the makeup of the first year courses.

This survey asked students to reflect on their experience with the EWB AU Challenge, and to consider how it had impacted the development of their technical and professional skills, altered their perception of engineering, and developed their understanding of the role of an engineer. The survey was adapted from the post course survey administered by CSU [7], which contained a series of Likert scales and yes/no questions aimed at gauging student reactions to the EWB AU Challenge. Total counts and percentages from student responses to the Likert scale questions are presented using the same methods displayed by Siller and coauthors for the purpose of comparison [7]. Statistical comparisons could not be conducted between universities due to a lack of access to the full CSU data set. To add further depth to the results of the Likert scale questions, students were asked to provide a short response to the following question: *Have your views on the roles of engineering changed as a result of the EWB AU Challenge? In what ways?*

Emergent coding techniques, described by Saldana [10], were used in the analysis of student responses to the short answer question. An initial code book was developed by researchers and updated with each coding cycle. Each of the three authors independently coded the student responses. Differences in coding were discussed amongst researchers after each coding cycle until interpretive convergence was reached. In this paper, initial emergent themes identified using this coding process are presented.

IV. Results

Results of the Likert scale questions are presented below, followed by the results of the open-ended questions.

A. Likert Scale Questions

In completing the survey, students were asked to rate how the EWB AU Challenge affected their understanding of each of the following on a 3 point scale (1 = Positively Affected, 2 = Neutral, and 3 = Negatively Affected):

- Q1: The role of an engineer within society
- Q2: The role of an engineer globally
- Q3: The importance of defining a problem
- Q4: How culture affects engineering decisions
- Q5: The needs of communities and organizations
- Q6: How communities and organizations affect the definition of the problem

TABLE I
Respondent Ratings: EWB AU Challenge

	MTU (n=69)			CSU (n=108)		
Likert Question	Positive	Neutral	Negative	Positive	Neutral	Negative
Q1	79.7%	20.3%	0%	86.1%	13.9%	0%
Q2	82.6%	17.4%	0%	87.0%	11.1%	1.9%
Q3	81.2%	18.8%	0%	81.5%	17.6%	0%
Q4	76.8%	23.2%	0%	75.0%	23.1%	1.9%
Q5	85.5%	14.5%	0%	77.8%	19.4%	2.8%
Q6	75.4%	24.6%	0%	71.3%	25.9%	2.8%

Results from the Likert scale questions from both CSU and MTU are shown in Table 1. The results reported for CSU in table 1 were obtained through digitization of a figure presented by Siller and coauthors for their 2015 EWB AU Challenge cohort [7] using Plot Digitizer. In digitization of the provided plot, an error of 1.85% is observed due to potential superimposition of the plotted data points.

Student responses indicate an overall positive impact of the Challenge on their understanding of each of the Likert prompts. In fact, the results indicate that over 75% of the students found the Challenge to positively impact their understanding of each of these categories.

B. Open Ended Reflection - Role of an Engineer

Analysis of student responses identified several emergent themes, each comprised of related codes identified by researchers during the convergent coding process. A summary of these themes and their associate codes are described below.

- Contemporary Engineering: real world engineering, humanitarian engineering, global scale engineering and broadness of project scope.
- Project Relevance: reinforced views on engineering, no project relevance/relation to engineering major.
- Design Thinking (Stanford Model): design process, empathize, define, ideate, prototype, and test.
- Traditional Engineering: role of engineer in society, role of engineer on project, technical skills, problem solving, and project management.
- Communication: collaboration between engineers and with community/stakeholders.

a) Contemporary Engineering: The theme of contemporary engineering was the most prevalent within student responses, with 35 of the 69 EWB students (50.7%) reflecting on this topic. Through participation in the EWB AU Challenge, students gained a sense of the role engineers can have in making a real-world difference across a wide variety of projects. This theme included student responses which emphasized the opportunity that engineers have to help the community and participate in humanitarian projects, often citing the impact that engineers can have on global communities One student reflects, *"I realized that engineers can do many things to help improve society all around the world..."*

Also included in this theme were student responses pertaining to the interdisciplinary nature of engineering and the broadness of project scopes and tasks engineers are expected to complete. Student responses highlight how the EWB AU Challenge expanded their understanding of the role of an engineer, as demonstrated in the following student quote, *"It showed me broader aspects of engineering and that engineers can do many diverse projects around the entire world. As first years, we're pretty new to engineering so I think this just opened up to the variety of opportunities engineering presents."*

b) Project Relevance: In reflecting on the impacts of the EWB AU Challenge on the perceived role of an engineer, student responses also highlighted their perceived value of the project itself. Some student responses (27.5%) indicated that this project did not alter their perception of the role of an engineer, as the project was not relevant to their major or did not change their views on engineering. However, some students (9.7%) indicated that the project reinforced their views on engineering and validated their choice to pursue their major. In recognizing this, one student reflected: *"I don't know if my views have changed as a result of this course but it has reinforced some of my ideas about what an engineer is."*

c) Design Thinking (DT): Concepts of Design Thinking were introduced to students participating in the EWB AU Challenge as a part of the course learning content. These students were tasked with employing each of the 5 phases of DT (empathize, define, ideate, prototype, and test) [5] while completing their project for the Challenge. In total, 13 (18.8%) EWB students reflected on the DT framework when asked to reflect on the impact the EWB AU Challenge had on their perceptions of the role of an engineer. One student commented, *"I think this class is structured in a way that allows students to get a better idea of how projects may be structured in industry. This really allowed me to understand what the roles of different engineers...it helped drive home the idea that they will play a part in the process from creating a design to implementing it."*

While comments regarding the general design process were found in student responses, reflection on each of the phases of DT were also present. Of these phases, the empathize phase was most prevalent within student reflections (7.2%). This phase places emphasis on understanding the needs, culture, and values of the people through observation and engagement with community members [5]. Students highlight the role that empathy plays in engineering, especially in connection to making appropriate design decisions. This sentiment is expressed by a student who wrote, *"One impact...was taking into consideration challenges and limitations different environments can place and that designs that are commonplace in one context do not universally apply to all contexts."*

Reflections on each of the other DT phases were also encountered. Specifically, student reflections emphasize the importance of clarifying design intent, generating and prototyping design solutions, and testing those solutions to obtain constructive feedback.

d) Traditional Engineering: The role of an engineer, defined in student responses, also included components related to traditional engineering skills, including problem solving and project management. The importance of these skills in successful completion of the EWB AU Challenge and their connection to the role of engineers are echoed throughout student reflections, with 16 of the 69 (23.2%) surveyed student responses containing codes pertaining to traditional engineering. One student writes, *"I feel like I better understand the documentation and such that would go along with a project like this."*

Student responses also highlighted the perceived role of an engineer within a project setting. These comments reflect the role an engineer plays in providing leadership to the project team, managing project logistics, and implementation of the design solution.

e) Communication: Finally, topics related to communication were also prevalent in student responses. The importance of being able to communicate, across disciplines, with other engineers and the communities they serve were highlighted in student reflections. One student wrote, *"I understand more about the collaborative side of engineering, as well as receiving input from other engineers about one's own work."*

In addition to highlighting the engineer's role in communication within project teams, student responses also indicated the importance of being able to effectively communicate with project participants and the public.

V. Discussion

The purpose of this study was to validate the results obtained by CSU and to provide further context to the Likert question results. The CSU Likert question results from their 2015 EWB AU Challenge cohort echo those presented in this paper, with more than 70% of students indicating a positive effect of the Challenge on their understanding of each of the prompts and less than 5% of participants indicating a negative impact [7]. The similarity of the survey results across institutions and project years suggests that the results obtained are not reflective of the specific course instructor, university, or EWB AU Challenge topic (host community) for the respective year, and pertain more to the experience of participating in the Challenge. Although, it should be noted that, lacking the data set from CSU, statistical conclusions cannot be drawn.

When comparing the results of the Likert scale questions between CSU and the focus institution, some interesting insights are observed. CSU students from the 2015 Challenge cohort reported that the Challenge had the highest positive effect on their understanding of the role of an engineer globally [7]. In contrast, students from this study ranked this category as second highest, and reported the greatest positive impact to their understanding of the needs of communities and organizations in the context of the project. The difference in these results might be attributable to the integration of the DT framework into MTU's FYE course. This framework includes the empathize phase which places emphasis on understanding the needs of the client, their values, and their culture [5]. Thus,

student exposure to the empathize phase of Design Thinking may have resulted in greater exposure and understanding, beyond what is traditionally observed in the EWB AU Challenge, to the importance of understanding the needs of the clients.

The EWB AU Challenge is structured to develop a holistic skill set in engineering students, including the ability to work in a global context, understand the social and ethical responsibilities of an engineer, and the ability to communicate and work effectively in teams [4]. Previous work on the EWB AU Challenge indicates success in developing these skills and knowledge, especially in preparing participants to work in global engineering settings [12]. In fact, in a study conducted by Cook and coauthors [11], it was found that participation in the EWB AU Challenge led to increased student understanding and development of global preparedness in first year civil and environmental engineering students. The preliminary emergent themes presented in this study, especially when viewed in the context of the Likert question results, support the learning outcomes of the Challenge reported by EWB AU and in literature. Participating students indicated an overall positive effect of the Challenge on their understanding of the role of an engineer globally. When paired with the emergent theme of contemporary engineering, an emphasis on the subtheme of global scale engineering and global preparedness is observed. Student reflections highlight the skills necessary to successfully work in a global engineering environment, including an ability to understand and engage with the needs of the client and understand an engineers obligation to uphold social responsibility.

Studies on the learning outcomes of the EWB AU Challenge also support the development of effective communication skills and exposure to real-world engineering projects. In a study conducted by Buys and coauthors [12], the impacts of integrating the EWB AU Challenge into FYE courses at 13 Australian (AU) and New Zealand (NZ) universities was investigated. Interestingly, student focus groups expressed similar attitudes in terms of benefits and downfalls of the EWB AU Challenge even though the instruction techniques, course integration, and assessment methods were different across the universities. Student reflections emphasized the value of project participants completing a real-world project with real clients and stakeholders. However, participants indicated that the EWB AU Challenge presented difficulties in communicating within project teams and with the host community.

Similar sentiments are echoed within student responses from this study in terms of exposure to real world engineering projects and concepts. When asked to reflect on how the EWB AU Challenge influenced their perception of the role of an engineer, student responses from this study highlighted the importance of gaining exposure to real world engineering projects. The theme of communication was also present in the student reflections of this study. However, in contrast to the responses obtained from students in the Buys and coauthors study [12], reflections from this study did not highlight any challenges in communicating within project teams or with the clients of the project. A lack of challenge related to team communication could be a result of the flipped classroom format that the FYE courses in this study follow. These courses are designed to promote peer learning and incorporate aspects of teaming. Thus, exposure to these concepts prior to beginning the Challenge (through course learning content) could lead to the lack of complaints. Difficulties in communication with the project participants and clients were also absent from student reflections in this study, which could be due to the difference in university schedules. U.S. university schedules are behind those of AU and NZ by one semester. Thus, Challenge resources were openly available to our students from the beginning of the project whereas AU and NZ students gained access to resources throughout the duration of the Challenge [5].

VI. Conclusion

The EWB AU Challenge presents participating students with the opportunity to engage in real-world, global-scale engineering design projects through a modified service learning format. While the Challenge does not allow for direct interaction between students and the participant community, it does provide a low-cost, low-risk opportunity for students to engage in real world, global design and retain some of the social and moral benefits of service learning. Student reflections towards the Challenge were overwhelmingly positive, with nearly 75% of participating students indicating a positive effect of the project on their understanding of the role of an engineer, the needs of communities, and the importance of being prepared to work in an international setting. The emergent themes identified in student reflections suggest an increased understanding of contemporary engineering and the acknowledgement of the importance of these skills in the role of an engineer. However, further work is needed to effectively evaluate the impact that the EWB AU Challenge has on the development and evolution of student perception of the role of an engineer. Development and administration of pre-post surveys could provide further insight into specific, measurable influences of the Challenge, accounting for student perceptions of engineering and the role of an engineer at the beginning as well as during the course. Additionally, investigation into student major should be conducted because it may provide insight into differences in perception of the role of an engineer.

The authors recommend integration of the EWB AU Challenge into FYE courses at other U.S. institutions in an effort to prepare engineering student to work in a globalized world. Additional U.S. participation is needed to validate the findings of this work. The authors encourage future participants to place additional consideration to the impact of individual course design and supplemental course learning content and objectives because it may be the link to further enhancing the learning outcomes of this opportunity.

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