Student Perceptions of the Role of an Engineer Prior to Completing First Year Design Projects

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***Abstract*— This work in progress paper presents baseline data from a study exploring student outcomes from participating in the EWB AU Design Challenge. Findings presented in this paper explore initial student perceptions of the role of an engineer reported prior to participating in the Challenge. This study builds on previous findings, providing richer detail about student understandings regarding what it means to be an engineer. To determine the influence that involvement in the EWB design challenge had on any potential shifts, course sections performing non-service-learning design projects were also surveyed for comparison. The ultimate goal of this work will be to compare pre-/post- surveys from both student groups. In this baseline data the cohorts appear substantially similar at the start of their courses.**

Keywords— first-year engineering, student perception, service learning, project-based learning.

I. Introduction

Service learning, a form of project-based experiential learning that introduces students to course concepts through participation in service projects within a community [1, 2], is increasingly being introduced into engineering curricula [1, 3]. Within the engineering education literature body, participation in these service-based learning interventions has been linked to numerous impacts including enhanced student learning and social outcomes [4]. Each year since 2007, Engineers Without Borders (EWB) Australia has issued a new FYE design challenge in partnership with a community organization. The EWB Challenge is issued through community-identified project briefs which target design areas and specific project needs for that community. Since its inception, the EWB challenge has grown and become embedded in engineering programs at universities throughout Australia and New Zealand. Over 100,000 students have participated in the program since its inception [5].

In 2014, Colorado State University (CSU) became the first institution within the United States to integrate the EWB Challenge into its FYE course structure. Surveys of students who completed the Challenge at CSU found the experience positively affected their understanding of the roles of engineers within society and globally, helped them to see the importance of defining problems, and developed their understanding of how culture affects engineering decisions, including stakeholder needs, especially around problem definition [6]. In 2020, Michigan Technological University (MTU) became the second university within the United States to participate in the EWB Challenge. Post-challenge surveys of their students found similar student outcomes as those reported by CSU [7]. Taken together, these studies indicate that the results were not unique to the universities, instructors, or projects of that given year, but likely a result of participating in a global development focused service-learning project. However, questions remain as to whether the changes in students' perceptions of the role of an engineer are unique to the EWB experience or if they were simply a result in participating in project-based learning. To investigate the implications of the EWB project on student understandings of what it means to be an engineer, the following research question is presented: Do students who participate in service-learning vs. traditional project-based learning gain different understandings of the role of an engineer?

II. Study Design

To investigate the identified research question, students enrolled in FYE courses at two institutions were surveyed prior to beginning the course and after completing the FYE projects. Results obtained from this observational study are based in the student self-reported responses obtained from the pre-post surveys. Constructivist learning theory [8] is employed as a theoretical framing for this work. A full discussion of the theoretical underpinnings for this study will be provided in forthcoming work exploring the full results.

A. Positionality

As researchers, we recognize the vital role that our individual identities and experiences play throughout the entire research process [9, 10]. As such, we provide a brief positionality statement to our readers as a lens through which to view this study. All authors of this work are white females with a background in engineering education research. Amanda Singer is a former graduate student of MTU who's previous research serves as the basis for this work. She previously worked as a teaching assistant within the FYE department at MTU and was

involved in the development of the survey for this study. Dr. Margot Vigeant is a faculty member in the Department of Chemical Engineering at Bucknell University. She has taught and directed the FYE course in the past but is not at present involved in the course. Dr. Michelle Jarvie Eggart is faculty in the Department of Engineering Fundamentals at MTU. During the semester that the survey was administered to students, she was the instructor of the FYE course offering that completed the EWB Design Challenge as the semester project.

B. Participants

Participants of this study included students enrolled in first-year engineering (FYE) courses across two institutions. At each of the participating universities, engineering students complete a standard sequence of engineering curricula during the first year of study which includes an introductory-level engineering course. At Bucknell, this required course is taken during their first semester of engineering study (fall semester.) At MTU, the introductory engineering requirement is comprised of a two-part course sequence that FYE students take during the Fall and Spring semesters of their first year [13]. FYE students enrolled in the introductory engineering courses at both institutions are required to complete at least one engineering design project as a part of their final grade (this project is completed during the spring semester at MTU.) A summary of the FYE design projects that were offered to participants of this study at each institution as well as the number of students enrolled in each section of the course offerings are included in Table 1.

TABLE I. SUMMARY OF FIRST-YEAR ENGINEERING COURSE PROJECTS

University	Course Offerings	Semester Design Project Topic	Students Enrolled (#)
Bucknell University	N/A (Each student does two projects)	SUNsational Addition	206
		Smart Sustainability App	
		The Power of Ray	
		Building Better Biosongestion	
		Keeping the Fluid Flowing	
		Trash to Cash	
		Making a Building Smart	
		Enabling Sustainable Agriculture or the Future	
Michigan Technological University	Section 1	EWB AU Design Challenge	95
	Section 2	Microbrewery Design	166
	Section 3	Robotics Design	207
	Section 4	Adaptive Bike Design	178

At Bucknell, students enrolled in each of the sections of the required FYE design class were invited to participate. Responses were collected only from students who were at least 18 years old and consented to be part of the study (n=152.) The fall 2021 class was 33.2% female identified based on admissions data [11].

At MTU, students enrolled in the second semester of a required two-part engineering course sequence were invited to participate. In the fall of the 2021- 2022 academic year, the FYE program students were 27% female self-identified [13]. Survey responses were only collected from students who were at least 18 years old and consented to be part of the study (n=515.)

C. Data Collection

Pre- and post- project surveys, based on previous work conducted by the authors [7] were utilized as the data collection tool for this study. The pre-post surveys were adapted to include a mix of Likert scale, open-ended short answer, and sorting questions, and were administered to participants using Qualtrics. Self-report questions within the survey addressed background demographics, student major choice, the role of an engineer within society, and perceived tasks of an engineer. Additional questions which asked for student-specific information for the purpose of pre-post matching were also included within the survey. Informed consent was obtained from participants for each survey (pre- and post-). Study activities were reviewed by IRB staff at both universities and deemed exempt from full board review at either.

D. Data Analysis

In the present work, pre-project student responses from questions related to the role of an engineer in society are shared, consisting of five Likert scale questions and one sorting question. Student responses to Likert-scale and sorting questions were collated in Qualtrics for all consenting students. Likert-scale results from the pre-project round of surveys are presented as within the results section as simple histograms. For the sorting question, the top 5 most prevalent responses for each category are presented as percentages. Future manuscripts will present the post-project results of the study and discuss the overall change in student perception across the pre-post results.

E. Limitations

One challenge with a pre-test asking students about their perceptions of engineering-related behaviors, attitudes, and skills is that, as FYE students, respondents may not yet understand what terms mean in the same way that they will by the end of the course. The students at the two institutions are in different semesters, their first in Bucknell, the second at Michigan Tech. At MTU, all students self-select into their engineering classes and associated projects. Thus, the data does not represent the impact of the project on a random sampling of students.

III. RESULTS

Results obtained from the pre-project surveys are presented below for selected questions pertaining to the baseline student perceptions on the role of an engineer. The baseline results are delineated by institution, with the results from the EWB AU Design Challenge section (service-learning) being separated from the other design projects offered at Bucknell and MTU (traditional project-based learning format.) This section of results presents initial data for five of the Likert style questions which pertain to student perception of the role of an engineer as well as results from the sorting question.

A. Likert Scale Questions

Within the pre-project survey, participants from each institution were asked to rate their feelings toward each of the following statements on a 5-point scale.

Q1. I see engineers as positive influences on society.

Q2. I see engineers as having an impact globally.

Q3. I see culture as having an impact on engineering decisions.

Q4. Time spent communicating with people and organizations about their needs, wants, and preferences, is time well-spent during the design process.

Q5. I am interested in pursuing international opportunities in the field of engineering.

Summaries of student responses to each of the 5 Likert style questions are depicted below in Figures 1, 2, and 3. Responses from students enrolled in the traditional project-based learning style courses at both Bucknell and MTU are presented in Figures 1 and 3 respectively. Initial results for students enrolled in the EWB section of the introductory FYE course at MTU are depicted in Figure 2. As students at MTU are informed of the semester projects prior to the course enrollment period, students are able to self-select the semester project they wish to participate in by signing up for that course section. Student responses from the EWB section of the FYE course are presented on their own to see if the baseline perceptions of these students are differentiated from the baseline responses of students enrolled across the other projects.

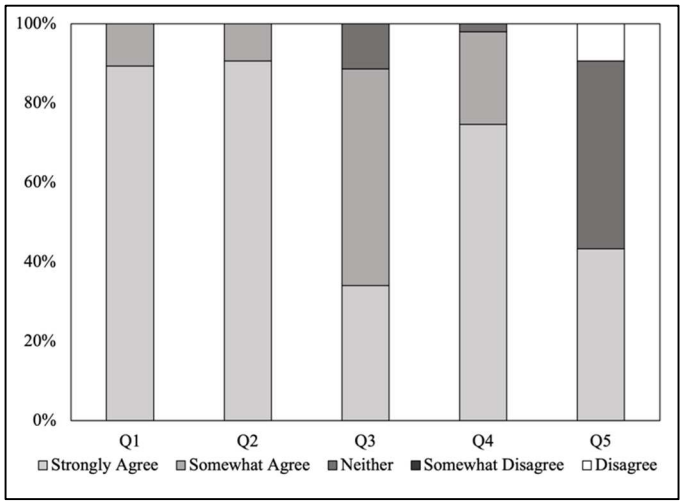

Figure 1: Likert Results for Bucknell University (Non-EWB Projects)

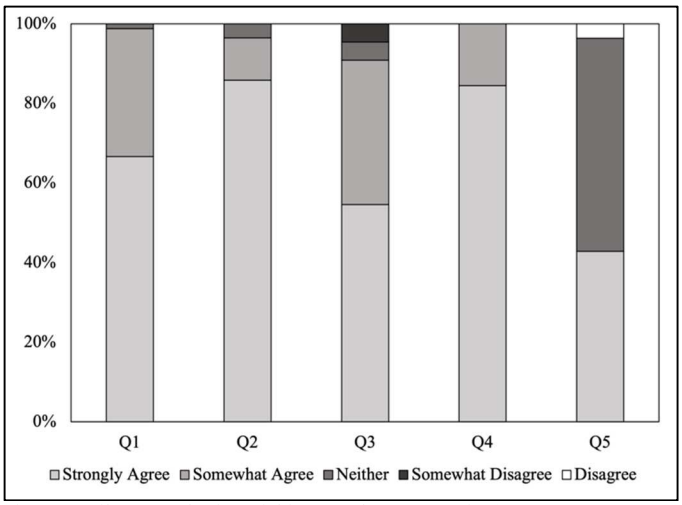

Figure 2: Likert Results for Michigan Tech (EWB Project)

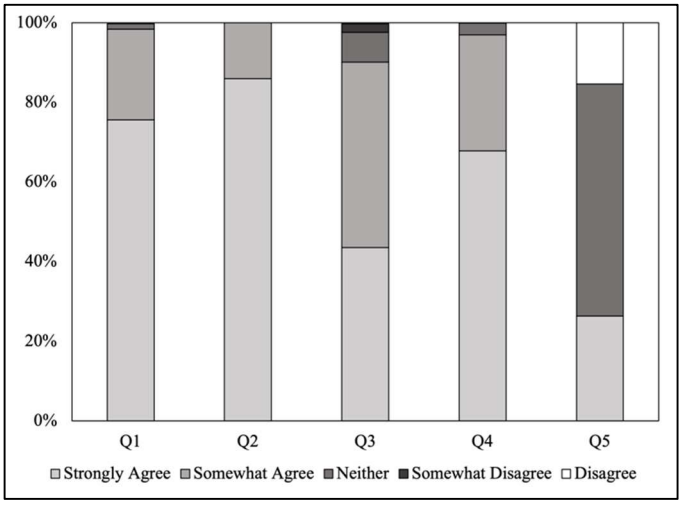

Figure 3: Likert Results for Michigan Tech (Non-EWB Projects)

B. Sorting Question

To obtain a baseline understanding of FYE student perceptions on the role and responsibilities of an engineer, students were asked to sort a list of words and phrases into categories of "very much describes the role of an engineer," "somewhat describes the role of an engineer," and "may or may not describe the role of an engineer." The phrases included within this sorting activity were identified from previous work conducted by the authors and emergent themes within the engineering education literature body. Terms that contrasted the themes identified within literature were also included to provide students with a diverse pool of sorting options that may or may not pertain to the role of an engineer. The top 5 results in the "very much describes the role of an engineer" and "may or may not describe the role of an engineer" sorting groups are presented in Table 2 for Bucknell and MTU.

TABLE II. PRE-TEST RESULTS OF SORTING QUESTION (BUCKNELL [N1]=152, MTU [N2] = 515)

Rank	"Very Much Describes and Engineer"				"May of May not Describe an Engineer"			
	Bucknell University		Michigan Technological University		Bucknell University		Michigan Technological University	
	Sorting Option	*Response Rate (%)*	*Sorting Option*	*Response Rate (%)*	*Sorting Option*	*Response Rate (%)*	*Sorting Option*	*Response Rate (%)*
1	Solves problems	81.6 %	Solves problems	80.0 %	Tracks the project budget	49.3 %	Tracks the project budget	56.5 %
2	A collaborator with other engineers	77.0 %	A designer	72.0 %	Responsible for societal transformation	36.2 %	Responsible for societal transformation	35.0 %
3	A designer	75.7 %	A collaborator with other engineers	70.9 %	An empathizer	35.5 %	Maintains the project schedule	28.0 %
4	An idea generator	69.7 %	An idea generator	68.9 %	Writes reports	32.2 %	Works with other countries/ cultures	26.8 %
5	To define problems	65.8 %	To define problems	60.6 %	Responsible for client/ community communication	30.3 %	Delivers presentations	24.5 %

IV. DISCUSSION OF RESULTS

The overall student responses to the Likert questions indicates strong to somewhat agreement across institutions and projects that engineers are positive influences on society and that they have an impact globally. Student participants enrolled at Bucknell demonstrated stronger agreeance to Q1 and Q2 compared to their MTU counterparts. Students across both institutions also generally agreed that time spent communicating with stakeholders during the design process is time well spent. However, differences arose in the results of student responses when considering the role of culture in engineering. Student participants from Bucknell reported a slightly stronger agreement that culture has an impact on engineering design compared to student respondents from MTU. In fact, student participants from MTU reported some disagreement regarding the role of culture. Across the three participant populations, students enrolled in the EWB project section at MTU were more likely to report interest in pursuing global engineering work compared to their peers in other project sections at the same university. However, student reported levels of interest in global engineering work was similar between Bucknell and the EWB section of MTU, which may be evidence of bias due to student self-selection of project through course offering selection at MTU. We anticipate this question may diverge even further by institution and section by the post-test.

By and large, all students appeared to be enthusiastic about engineering's ability to help solve problems in the world. A later goal of this study is to assess the impact of project-type and client on students' perceptions of the role of an engineer. In responses to questions 1-2, there is not much room for students to become *more* convinced that engineers are positive influences on society and have a global impact.

The sorting task is perhaps most telling about students' perceptions of engineers. Currently sorted by institution only, future work will address the differences between the service learners and problem-based learners on this task. Again, while FYE students at the two institutions are not identical in their answers, there was a high degree of agreement between the two on which activities are most associated with the role of an engineer. The student respondents at the two institutions agreed upon all of the top 5 activities most strongly describing the role of an engineer.

For activities that "may or may not describe the role of an engineer," student respondents at Bucknell and MTU agreed on 2 of the top 5. Note that the strength these selections are moderated with respect to the phrases that "very much" describe the role of an engineer. While the majority of the students agreed upon the elements that describe engineers, 56% was the highest level of agreement found on any of the tasks less associated with engineering. The activities on the latter list mostly fell into professional skills, project management, and interpersonal skills. The authors anticipate experience with FYE projects, some of which involve clients from different cultures, will create movement and differentiation in this category.

V. CONCLUSION

Overall, the cohorts of FYE students at the two institutions did not display major differences in their perceptions of the role of an engineer prior to completing their projects. Future work will include significance testing between populations of students in the different projects.

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