A New Narrative: The Power of Story in Retaining Underrepresented Populations in Engineering

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Abstract

To increase the diversity of the student population in undergraduate engineering programs, institutions of higher education need to find ways of appealing to the motivations of different demographic groups. This study examines survey data from participants in an international humanitarian engineering project across a five-year period. The objectives of the study were to determine whether underrepresented student populations participated in the program at different rates than their peers and whether there were differences in their experience of the project itself. Initial results showed statistically significant differences in participation for women and LGBTQIA students, as well as statistically significant differences in motivation for program participation and perceptions of career outlook. The study concludes with a call for higher education institutions to broaden their sponsored programming to appeal to a broader student population and retain more diverse engineering student cohorts.

Introduction

The National Society of Professional Engineers Code of Ethics preamble states that "Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare." [1] The National Academy of Engineering's report on the fourteen Grand Challenges speaks to the "smaller, more inclusive, more connected world" that remains inequitable in the proliferation of engineering solutions for modern challenges [2]. They challenge current and future engineers to not only consider the challenges facing global society but also consider how all of humankind and the planet can benefit from future innovations, not just those living in the more developed nations. These national organizations challenge engineers to leverage technical expertise and innovation from a position of global community engagement.

While every engineering discipline supports work that directly impacts human quality of life, not all engineering educational experiences connect technical competencies to their impact on global citizens and the world at large. However, it is this engagement with the global community that motivates many incoming students to pursue engineering in the first place [3]. Humanitarian engineering projects allow students to connect their technical skills to global concerns, putting into practice engineering knowledge in a community setting. As a majority of these experiences are enacted as co-curricular or extra-curricular activities, involvement with these projects is typically voluntary [4].

This study seeks to better understand the students' choosing to engage with these experiences and how their experiences meet their desire to engage with a global community while making use of their technical skills. Through data gathered by an international humanitarian non-profit organization serving developing nations, this study examines how underrepresented populations in engineering programs experience increases in self-efficacy and motivation to pursue engineering careers through these projects. These students resonate deeply with both the

community of fellow students who share values for bettering their world and with the global community with whom they work alongside in completing engineering endeavors. Their experiences correlate to indicators for higher levels of persistence in engineering education and engineering careers, aligning with previous studies regarding humanitarian engineering work [5]. These students also encourage others to participate in such experiences. In other words, their stories of engineering engagement positively impact other engineers, often underclassmen, to pursue similar experiences.

This paper opens with a brief review of literature examining the benefits of humanitarian engineering projects and the limitations of current methodologies for project deployment. The review of literature continues with systemic and institutional barriers experienced by engineering undergraduate students, especially those in underrepresented populations. Background information about the humanitarian organization is provided to contextualize the data collection and analysis for this study. The methodology describes the survey instrument and method of data collection. The data analysis follows, as well as a discussion of the results. In this section, special attention is given to underrepresented populations, including women and those who identify in the LGBTQIA community. Finally, recommendations for applying lessons learned, as well as opportunities for ongoing research are presented.

Review of Literature

This study is founded on two key considerations. First, humanitarian engineering work is a powerful mechanism for engaging engineering students with their profession and the global community. This blend of technical skills and social engagement has been shown to encourage engineering students to persist in their chosen fields beyond graduation and into the workforce. Second, institutional systems can create barriers to persistence which disproportionately impact underrepresented populations, such as women and the LGBTQIA community. The intersection of these two considerations is the basis for the analysis conducted in this study.

Humanitarian Engineering Projects and Engineering Students

The ABET (Accreditation Board for Engineering and Technology) Engineering Criteria 2000 (EC 2000) emphasizes the need for future engineers to demonstrate proficiencies in multidisciplinary teams, engineering in a global context and an understanding of contemporary issues [6], among other technical skills. This act was lauded by the National Academy of Engineers (NAE), in their report “Adapting Engineering Education to the New Century” [7] in which the academy noted the increasing disparity between engineering practice and engineering education. In their report, they stated that while engineering faculty had previously demonstrated resistance to change, the increasing interdependencies of societal needs and technological solutions required engineering education to better prepare students for multidisciplinary work in a global context.

The call to action raised by the NAE and other organizations has been echoed by engineering education researchers ever since, with the seminal work of Donna Riley [8] recognizing that engineering education continues to train future engineers in traditions of consumerism, individualist beliefs and functions within existing power structures, rather than within societal

contexts. More recent studies evaluating engineering education research and current engineering curriculum note that engineering faculty largely maintain that studying the humanities is irrelevant to engineering education and pose engineering problems devoid of any social context [9-14]. However, engineering students matriculate into their programs with aspirations of addressing global challenges using technical innovations, even if that is not how the material is framed in the classroom [6].

Researchers in engineering education affirm that the skills required to integrate technical knowhow from a global context, are not innate but must be intentionally integrated into the curriculum for students to practice engineering from these perspectives [12, 14]. Roscoe et al. stated that "the solution for many pressing challenges requires engineering innovations that are guided by a keen awareness of human goals, needs, abilities and limitations" (pg. 404) [13]. While humanitarian projects for engineers, such as the work with Engineers Without Borders, Engineers in Action and other project-based learning applications have shown themselves to be effective in increasing awareness of cultural dimensions and skills of communication and teamwork [5, 8, 9, 14], these activities remain as extra-curricular experiences where students predisposed to interest in humanitarian work can volunteer their time and technical skills.

As an extracurricular activity, with little formal instruction, there is the danger that without intentional planning, humanitarian engineering projects can disenfranchise the very communities they are trying to help [16]. Students must engage with the project from a perspective of blended boundaries that meaningfully engages with both the facts and values of a project – values which must be considered from the perspectives of all peoples. This view is not one traditionally held by engineering systems, which often embrace traditional power roles, making determinations on who is worthy of being served [11, 15].

To evaluate these concepts properly, previous research has determined a significant gap adequately capturing students' attitudes [10,11 13] and how they change as they grow in understanding of the differences in perspectives and values of other cultures and societies. This work specifically addresses this gap by analyzing the student's perceived change in technical, social, global and leadership skills. Furthermore, students provide insight into their motivation for pursuing these opportunities and the impact these projects have on their future careers.

Institutional Considerations and Barriers for Underrepresented Populations

Students applying for college do not face an easy task. Those who apply as high school students do amidst one of the busiest and, often, most stressful times in their lives thus far [17]. While they are trying to choose an appropriate institution to attend in the short term, they are also expected to plan long-term for what kind of career that enrollment will lead to [18]. While students typically pick a major course of study based on interest in that field, they expect that completing the institution's program will enable them to find a high-paying job [19].

Amidst this pressure of applying and having to make long-term plans at a young age, college applicants also need to parse unclear messaging from universities. Institutional mission statements, which inform their marketing to applicants, are often designed to attract applications rather than be reflective of the "lived mission" of those institutions in practice [20, 21]. Even if

institutions try to hold a unifying mission that will manifest in each student's experience, that becomes more difficult the larger an institution becomes. This is a product of "organizational anarchy," in which the mission and priorities of institutional sub-units become more decoupled the more complex an organization becomes [22].

Specifically with engineering students, Vohra, et al. [23] found that the most successful students with higher intrinsic motivation. This acknowledges that while most students may have more ends-focused motivations, those who perform the best see success in classes as inherently rewarding. This aligns with Stolk, et al. [24] who found that engineering students in a more selective college were more likely to be driven by intrinsic motivation in their coursework.

Women, in particular, are likely to face disparate experiences in engineering education. Women in introductory engineering courses are less likely to report confidence in their own academic skills [25]. As long as trends have been observed, women have dropped out of STEM programs at higher rates than men [26]. Women are more likely to doubt their own academic skills in engineering, even if they perform at the same academic level as men and are less likely to find encouragement to persist from their male peers [27, 28].

Students who drop out will often attribute that outcome to a lack of personal ability, even if they were not given adequate support to succeed by their program. Engineering traditionally relies on a culture of meritocracy, claiming that the most capable students will succeed and the least capable will not [29]. Because meritocracy, as an ideology, says that success or failure is product of personal capacity, those students who drop out are more likely to blame their own efforts rather than blame a system which failed to support or include them [30].

LGBTQIA engineering students face similar disparities to women students. These students are both less likely to enroll in STEM programs and less likely to persist through graduation [31]. Much like with women, LGBTQIA student dropout rates are associated with a lack of "sense of belonging" in their major [32]. Many LGBTQIA students perceive engineering as a discipline to have a culture that is inherently unwelcoming to them [33].

In this paper, we address one way that universities can, despite their institutional complexity, provide programs which welcome and encourage the diverse student populations they are most at risk of losing.

Contextual Background: Engineers in Action

While there are numerous humanitarian engineering organizations that provide opportunities for students to apply engineering knowledge in real-world setting, this study focuses on the experiences of those who choose to participate with Engineers-in-Action, a non-profit organization based in Oklahoma. This organization has several global initiatives in which engineers volunteer their time and expertise to aid communities in need. Their student-led Bridge Program involves the design and construction of pedestrian bridges in areas where geological conditions, such as gorges and rivers, prevent residents from being able to access critical services, such as medical care, schools, churches and markets. These student-led bridge projects have been completed in in numerous countries, with a current focus in Bolivia and Eswatini.

For the student-led bridge projects, students from participating institutions are divided into teams and assigned specific locations which have been identified by EIA and local constituents as suitable bridge sites. EIA staff works year-round with government agencies of both countries to determine locations that experience high need and can provide the resources to assist in the bridge process. Each project requires a community that is willing to aid in collecting materials and willing to participate in the physical construction of the bridge. The community also must be willing to host the team, which will include students, professional engineers, and masons and provide lunch for all workers on site every day. This collaboration is somewhat unique to Engineers in Action and requires the community to be highly involved in daily participation of the build. As such, students participating gain both engineering experience and experience interacting with other cultures. As will be seen later in the data analysis, many students noted this collaboration with the community as a significant reason for choosing to participate in these projects.

The projects occur over a full academic year, with design taking place in the late fall and early spring semesters and the building process occurring over the summer break. Designs are completed by students with the assistance of professional engineers (PEs), licensed civil engineers with experience in bridge design who officially sign the drawings. Additional engineers volunteer to spend their time on site during the building process to support the student team with unanticipated circumstances and to serve as quality assurance on projects. Faculty advisors from the institutions support the teams with fundraising, logistical support and engineering design support as needed. Student teams typically spend six to eight weeks in-country building the bridge. At the completion of the build, the students, community and local leaders and government officials celebrate the formal opening of the bridge. Local community members are taught how to do routine maintenance on the structure, which is designed to last more than 30 years.

Methodology

This mixed methods study involved the qualitative and quantitative analysis of data from a survey administered to participants in EIA student-led bridge building projects. The survey was developed by EIA staff and is distributed using GoogleForms. This survey is administered annually by EIA staff after the bridge projects have been completed. Student-led teams are required to complete the survey to be considered for future project opportunities, which ensures a high response rate, including all individuals who traveled to complete the bridge build. The data was provided to the researcher after all identifying information was removed. There were 23 collegiate institutions from the United States, Canada and the United Kingdom that participated in the 5 years for which data was collected. 537 respondents answered at least one question on the survey. While some questions were mandatory, students could choose not to answer every question, making the sample size differ by question. For the data analysis portion, the sample size is based on the number of responses to a given question, not the total number of surveys administered.

The survey is a combination of free responses and drop-down selections, in addition to demographic information. Related to their specific project, students record the country in which

the project occurred, the project year, and their project role. For demographic information, students record their institution, their academic major, their gender identity, their race and ethnicity, their sexual identity and their status as a domestic or international student. Students are asked to rate their overall experience on a range of 0 (very poor) to 5 stars (very good) and whether or not they would recommend the experience to a friend (yes/no). Students select "Improve/Did Not Improve/Not Applicable" to a series of four questions that address their professional and technical skills, which will be presented in more detail in the data analysis section. Students are given opportunities for short responses to questions regarding their reason for joining EIA, the impact the project had on how they viewed themselves, how they viewed their careers and how they will live their lives. These questions will be presented in greater detail later in the paper.

For the demographic questions, a comparison is made with gender and ethnicity compared to national undergraduate engineering enrollments. For the questions in which a categorical response was recorded, the data analysis addresses the population as a whole and then compares proportions by gender and sexual identity. For questions including free responses, a thematic analysis was conducted using key words to group similar responses and analyze them from the perspective of gender and sexual identity. Free responses were analyzed if the individuals had also included their demographic response for gender and sexual identity. As such, the data analysis will include the total number of participants for each individual question.

Presentation of Data and Analysis

The first analysis conducted was a basic exploration of demographic information provided by respondents. The demographic questions did not require completion, requiring an additional field of "prefer not to respond" as a potential outcome for the demographic data. For comparison with the undergraduate engineering populations within the United States, the authors compared the survey data to the 2023 report published by the American Society of Engineering Educators "Engineering and Engineering Technology by the Numbers" [34]. Figure 1 displays gender identity. The data provided by ASEE did not include categories for "Prefer Not to Say", nor did they capture genderqueer individuals, causing a slight disparity in the EIA gender totals. This figure demonstrates a much higher rate of participation of women. When the proportions of women were evaluated using Minitab, the proportion of females participating in EIA was found to be higher than national female engineering enrollment levels at a statistically significant level ($\boldsymbol{\alpha} = 0.05$), with a p-value of 0.000.

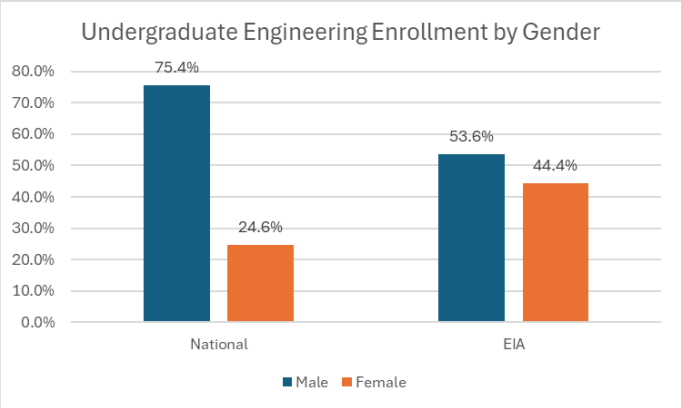

Figure 1. Comparison of gender identity for those participating in EIA with the 2023 ASEE undergraduate enrollment report.

Race and ethnicity of EIA participants were also compared to national demographics in undergraduate engineering programs, as reported by the 2023 ASEE undergraduate enrollment report. As seen in Figure 2, the proportions of individuals participating in EIA by ethnicity were similar, except for Latino, in which Latino participation in EIA exceeded the proportion of Latinos enrolled in undergraduate engineering programs at a statistically significant level. Using Minitab, the proportions were compared and at the 95% confidence level ($\alpha = 0.05$), the p-value was found to be 0.027, indicating a statistically significant difference in proportions. All other proportions were found to be comparable.

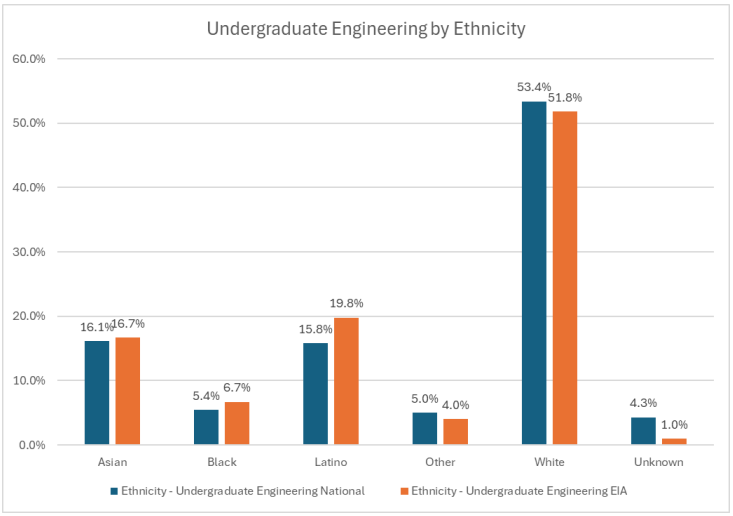

Figure 2. Comparison of undergraduate engineering enrollment and EIA participation by ethnicity.

As stated previously, the survey includes several qualitative measures for satisfaction and perceived improvements in technical and social skills because of the experience. It is highly commendable that in the 526 survey responses, only 6 individuals would not recommend the experience to a friend. That is an overall approval rating of 98.86%.

Exploring participant satisfaction more deeply, the survey has individuals rate the experience on a scale from 0 to 5, where 0 is “very poor” and 5 is “very good”. These responses were evaluated based on gender and sexual orientation, to see if there were any significant differences in the perceptions of participants based on gender or sexuality. These results are displayed in Figure 3. While there seems to be some variation between female responses at the 4.5- and 5.0-star levels, these differences were not statistically significant at the 95% confidence level. Using Minitab, the proportions of responses were compared across all three populations of interest. There was no statistically significant difference in any of the responses ($\boldsymbol{\alpha} = 0.05$).

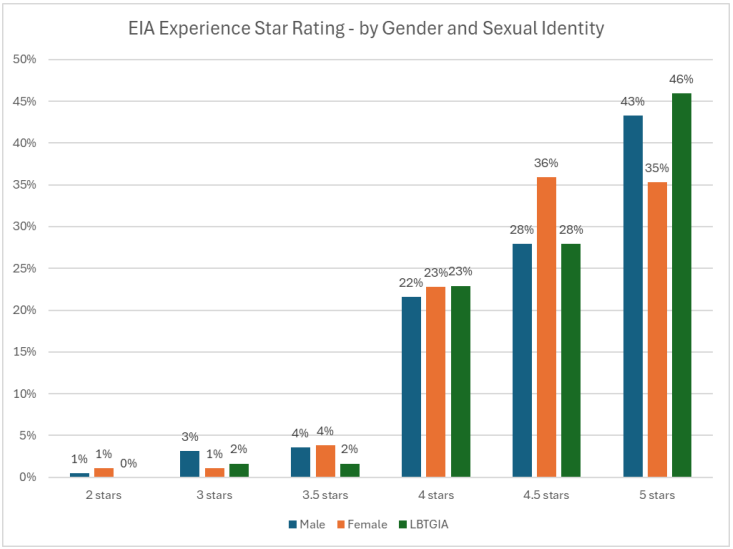

Figure 3. EIA star rating on overall experience, evaluated by gender and sexual identity.

For each of the four categorical questions, the researchers evaluated responses by gender and sexual identity to determine if there were any differences in perceived improvement in technical and social skills as a result of this experience. For these questions, students could select “Improve”, “Did Not Improve” or “Not Applicable”. All data was reviewed using MiniTab to compare the proportions of responses across the populations of interest. As will be seen in the following graphs, the populations respond similarly, with there being no statistically significant difference at the 95% confidence level. The results for each question are presented below.

The first question reads: “How did this project impact your ability to: [Apply engineering judgement and design principles within the scope of governing building codes and regulations to design an engineering system (e.g., footbridge, WASH system).]” As seen in Figure 4, over 80% of all respondents rated an improvement in their ability to apply engineering judgment in engineering systems.

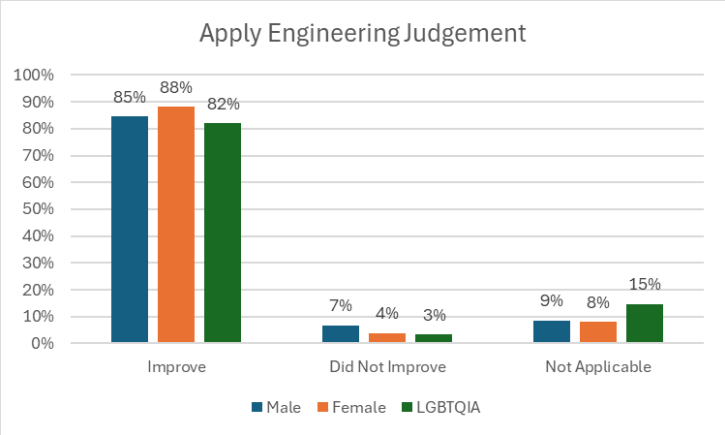

Figure 4. Respondents perceived change in applying engineering judgement to engineering design based on their experience with EIA.

The second question reads: "How did this project impact your ability to: [Collaborate effectively with external stakeholders (e.g., partnering NGOs, local municipalities, partnering communities, alumni, other EIA university programs, or sister academic institutions abroad).]" As seen in Figure 5, approximately 80% of all respondents rated an improvement in their ability to apply engineering judgment in engineering systems.

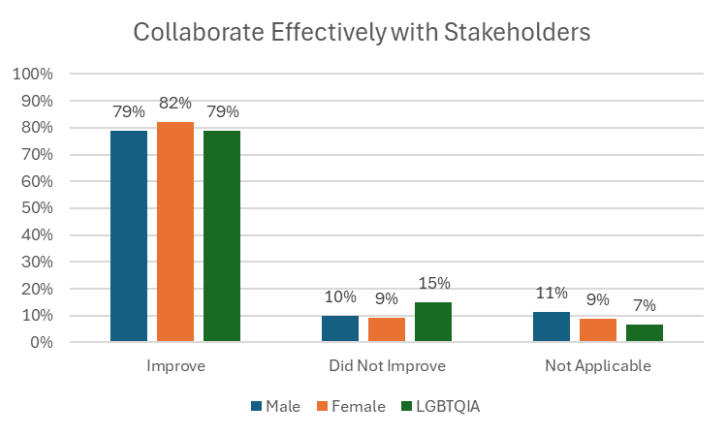

Figure 5. Respondents perceived change in collaborating effectively with various project stakeholders based on their experience with EIA.

The third question reads: "How did this project impact your ability to: [Adapt to overcome ever-changing adversity.]" As seen in Figure 6, over 90% of all respondents rated an improvement in their ability to apply engineering judgment in engineering systems.

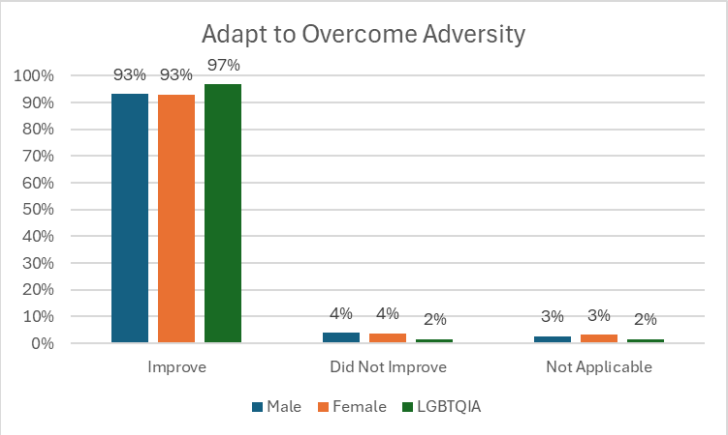

Figure 6. Respondents perceived change in their ability to overcome adversity as a result of their EIA experience.

The fourth question reads: "How did this project impact your ability to: [Pursue an engineering project from conceptual design to physical completion, implementing comprehensive project management skills in a team setting.]" As seen in Figure 7, over 85% of all respondents rated an improvement in their ability to apply engineering judgment in engineering systems.

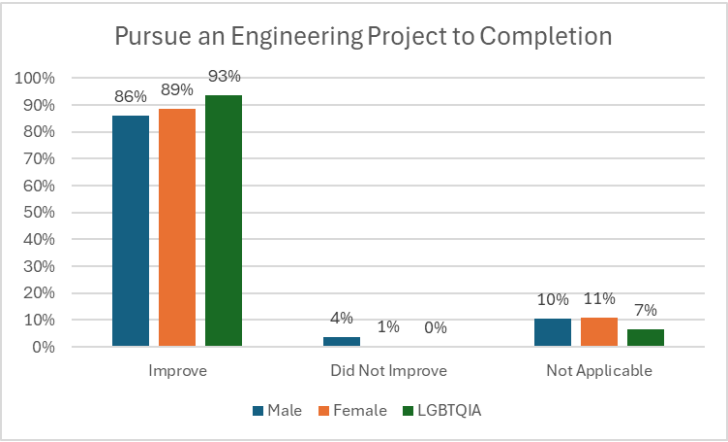

Figure 7. Respondents perceived change in their ability to pursue an engineering project from the design stage through completion as a result of their EIA experience.

The remaining questions were open-ended queries that were evaluated using a thematic analysis drawn from common words and phrases found in the responses. Not all respondents provided answers for each of these questions. As such, proportions of responses were based on the number of responses in accordance with their reported gender and sexual identity. Responses by individuals who did not include their gender or sexual identity were not included in the analysis. Student responses including more than one theme were recorded in each of the appropriate categories.

The first question asks respondents "Why did you join EIA instead of a different organization?". When reviewing the answers provided, eight themes emerged with notable frequency. The first and most predominant theme involved the humanitarian aspect of the work conducted by EIA.

Some students would use words like “service”, “help” or “give back”. These themes were grouped into the “Humanitarian” category. The second theme had to do with travel. Any response regarding traveling in general or specifically with EIA was captured in the “Travel” category. The third category had to do with applying engineering knowledge in a “real-world” setting or a desire for “hands-on” applications. All responses including these concepts were recorded as “Use Engineering Knowledge”. The fourth category had to do with gaining experience in engineering or developing new skills in engineering. Unlike the third category, which focused on being able to apply knowledge already possessed, this focus was on what a new experience could provide in developing further in engineering and technical skills. These concepts were categorized as “Develop as an Engineer”. The fifth category, like the fourth, focuses on gaining skills, however, these skills specifically name items like “leadership”, “management”, “project management” and “leading a team”. Concepts in this category were grouped as “Develop Leadership Skills”.

Another common theme addressed EIA’s mission and vision as a non-profit organization. In this category, students reflected a personal alignment to “values” and “mission” of EIA, creating a sixth category which was deemed “Aligned with Values”. Students also expressed a desire to directly connect with individuals from a different culture. Unlike those answers focused on the travel experience, these answers specifically named a connection and better understanding of cultures outside their own. These responses make up the seventh category, called “Connect with Cultures”. Finally, students specifically reference the interaction with the campus organization as being welcoming, engaging or finding a sense of belonging. Unlike the sixth category where students align with EIA values, in these instances, students have kinship with other participants in the club. This final category was labeled “Welcoming Club”.

These eight categories were evaluated with the frequency of responses calculated for males, females and members of the LGBTQIA community. The frequency of responses, with respect to total population size, was then compared using a comparison of proportions in Minitab. The proportions of responses for each group can be seen below in Figure 8.

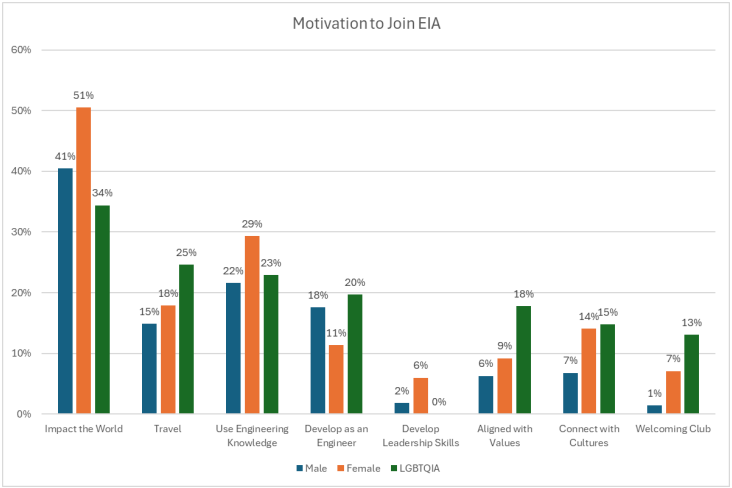

Figure 8. Motivation to join EIA based on the eight established categories by gender and sexual identity.

These motivational inquiries yielded some interesting dynamics between male, female and LGBTQIA respondents. It was found that a statistically significant proportion of women named a desire to make a positive impact on the world (Humanitarian) than both male and LGBTQIA respondents. It was also found that more women were seeking to increase their leadership skills (Develop Leadership Skills) and establish new cultural connections (Connect with Cultures) than both male and LGBTQIA respondents. Both female and LGBTQIA respondents listed the welcoming nature of the campus organization as motivating factors at statistically significant proportions when compared to their male counterparts. All proportions were examined at a 95% confidence level ($\boldsymbol{\alpha} = 0.05$). Table 1 contains the proportions and p-values resulting from the analysis in Minitab.

Motivation for Joining EIA				
	Male	Female	p-value	
Impact the World	41%	51%	0.043	
Develop Leadership Skills	2%	6%	0.033	
Connect with Cultures	7%	14%	0.016	
Welcoming Club	1%	7%	0.005	
	Male	Female	LGBTQIA	p-value
Welcoming Club	1%	7%	13%	0.0007

Table 1. Categories for joining EIA that represent a statistically significant difference between male, female or LGBTQIA respondents.

These responses are directly related to the themes of this research, as questions of belonging and self-efficacy are often seen as leading factors in lack of persistence in underrepresented populations in STEM education. Underrepresented populations (such as women, Latino's, LGBTQIA individuals and international students) are pursuing opportunities specifically to find community, while simultaneously developing the skills that will support a successful career in their chosen field. These values are also important to male respondents, however, the impact of this encouragement show's itself to be critical to persistence in the next set of responses.

This same process of creating categories for open-ended questions was followed for the survey question "How did this project affect your career outlook?". In this case, four major trends were seen in the student responses. First, commitment to ongoing work in humanitarian engineering was a key theme for many respondents, including: through working as a volunteer, pursuing work with an NGO full time, or working directly for EIA. This was captured as "Humanitarian Engineering". Several students stated an openness to working abroad for major corporations or pursuing opportunities overseas upon graduation as a result of this experience. These responses were captured as "Travel". For many, this experience confirmed their desire to pursue engineering careers. In some cases, students expressed doubt at their capabilities but now had the confidence to finish their degree. In others, students felt the experience affirmed what they had hoped, that they had the skills and desire to become engineers. These were recorded as "Confirmed Engineering". The last category is similar, but specific to Civil and Structural Engineering careers. In this case, several students mentioned the desire to change majors to

pursue Civil Engineering instead of their currently declared major. These statements, specific to Civil Engineering were captured as “Confirmed/Switch to Civil”. These responses can be seen in Figure 9.

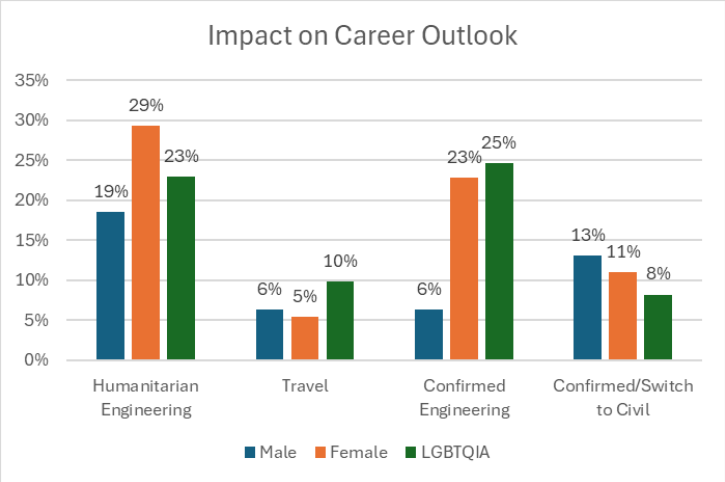

Figure 9. Responses to the impact the experience had on their career outlook by gender and sexual identity.

For these responses, a statistically significant difference was found between men and women on the desire to pursue Humanitarian Engineering programs beyond graduation. It was also found that both women and members of the LGBTQIA community more frequently referenced a commitment or confirmation in pursuing engineering careers. The proportions and corresponding p-values are presented in Table 2.

Impact on Career Outlook				
	Male	Female	LGBTQIA	p-value
Humanitarian Engineering	19%	29%	23%	0.01
Confirmed Engineering	6%	23%	25%	0.000

Table 2. Differing proportions on impact on an individual’s career outlook by gender and sexual identity.

Discussion

Using the survey from participants in the EIA Bridge Building Program over the past 5 years, it was discovered that the student chapters of EIA attract more women and LGBTQIA students, as well as international students than what are traditionally represented in national demographic data. When considering the known benefits of humanitarian engineering projects on student retention and professional development, this method of community engagement also serves as a method of retaining underrepresented populations in engineering education.

Furthermore, it was found that all participants equally appreciate increases in technical and social skills, as well as an increase in an ability to pursue engineering projects from inception to completion and overcome adversity. These reported benefits support previous literature that highlights the professional development experienced by those participating in community

engagement co- or extra-curricular activities. This is highly encouraging, as the demonstration of these skills are many of the reasons students pursue these experiences in the first place. This alignment between expectations and outcomes can also be seen in the nearly unanimous support for these experiences, as well as the high satisfaction rating across all participants. The positive nature of these experiences is part of what leads students to share their experiences with others.

Some students reported on their ability to share their stories with others. A few of these quotes from the survey are captured below:

"My company was super interested in hearing about EIA. I did a 50min 'knowledge share' on my work and travel, and everyone I talked to was super receptive."

"I described to one of my good friends on the project that the one word I would use to describe how I felt about the whole experience was 'alive'. I felt alive through the whole project and everyone else resonated that energy. I am looking forward to starting a career soon, and to start working on more real life projects."

"*Before this project, I wasn't really convinced that I wanted to be an engineer. In reflecting on just what made this project so fulfilling was that I loved the actual engineering aspect of it. My head was in the clouds before this trip, with dreams of peace corps and "making a difference" or just living out in the woods somewhere, but I am constantly reminded that it's actually engineers who get stuff done and that my education will situate me in such a way that I actually have tangible skills, and I shouldn't squander that."*

"This project is exactly the kind of thing I pictured when I chose civil engineering as a major, and it made me hopeful that I could find something similar to have as my career in the future because I enjoyed the work so much."

"I've always been on the fence on whether or not to continue being and engineer. After this, like i said earlier, it allowed me to see the impact engineers can do, and although i'm not a civil engineer, i still see the beauty in all engineering."

"It confirmed the path I want to follow and made me excited for the future to implement what I have learned."

This experience confirmed for many in our most at-risk populations confidence in their career choice, a passion for how that career choice can benefit the world at large and the "beauty in all engineering". These are stories that touch others, excite others and cause others to want to be involved in similar experiences.

When reviewing the motivations for joining EIA, students responded not only about the opportunities EIA provided, but the community of students that they would work alongside on their own campus. Students with powerful stories recruit other students to create stories of their own. While building a bridge in a developing nation adds unique aspects that are not captured in the majority of internships, undergraduate research experiences or classrooms, engineering remains a "beautiful" profession built on a foundation of pursuing a more equitable and verdant world for all of humanity. It is that narrative which will aid in attracting and retaining all students

in engineering, but especially those facing barriers due to an imbalance in representation or perceived lack of community.

Conclusion

Through this initial work, we have examined questions about participation by underrepresented student populations in a humanitarian engineering project. Initial findings from survey data indicate that student populations underrepresented in engineering, particularly women and LGBTQIA students, participate at disproportionately high levels in this project. While there were no statistically significant differences in self-reported proficiency outcomes for participants across identified demographics, there were significant differences in the qualitative responses regarding motivation for project participation and its impact on their career outlook.

One potential conclusion to draw from these findings is that women and LGBTQIA students are motivated by different ends than their peers. Humanitarian engineering projects like EIA may be able to appeal to those motivations in ways which disproportionately attract participation from these underrepresented student populations. The uniformity in disciplinary proficiency is not surprising since all participating students had similar professional development experiences, but the differences in career outlook could imply that those same experiences had different significance for the underrepresented student populations under consideration in this paper.

If universities are interested in building a more diverse cohort of engineering students, this indicates the kinds of programs that could help with that effort. Considering how impactful EIA was in confirming underrepresented students' enrollment in engineering majors, humanitarian engineering programs could be one way to maximize diverse student retention in engineering. If students from different backgrounds have different motivations for their participation in engineering projects, then institutions should consider offering a wider array of institutionally sanctioned learning experiences beyond the traditional academic sequence in order to appeal to students from different populations.

In a time where diversity, equity and inclusion efforts are being stripped from institutions, and supports meant to encourage marginalized populations are being defunded, the engineering education community must invest more heavily in educational activities which have been shown to enhance retainment of those individuals most likely to leave engineering career pathways. While EIA is only one of these experiences, future work could investigate the impact of other extra-curricular activities, in addition to embedded experiences such as internships, co-ops or senior capstone projects. Experiences which provide students with a connection to their peers and to communities, while reinforcing a sense of belonging to the engineering community are critical to retain those at risk. The researchers continue to work with EIA investigating the on-going collection of data, as well as a deeper understanding of the qualitative responses. Additional studies will also compare responses to these survey questions by participants of other student experiences, to evaluate the potential difference in impact of various engineering activities.

References

[1] National Society of Professional Engineers, "*Code of Ethics for Engineers"* Publication #1102, National Society of Professional Engineers, 2019.

[2] National Academy of Engineers, "NAE Grand Challenges for Engineering", Engineering Challenges, 2022. [Online]. Available: http://www.engineeringchallenges.org/challenges.aspx [Accessed: October 27, 2022].

[3] E. Cech, "Culture of disengagement in engineering education?," *Science, Technology and Human Values,* vol. 39, no. 1, pp. 42-72, 2014.

[4] W. Oakes, S. Khalifah, C. Sigworth, P. Fuchs and A. Lefebvre, "EWB-USA and EPICS: Academic Credit, Community Impact, and Student Learning," *International Journal for Service Learning in Engineering*, vol. 14, no. 3, pp. 29–48, 2019.

[5] A. Brown and M. Bauer, "Merging engineering education with service-learning: How community-based projects encourage socially conscious engineers," *Athens Journal of Education*, vol. 8, no. 1, pp. 9-22, 2021.

[6] ABET, "ABET History", About ABET, October, 2021. [Online]. Available: https://www.abet.org/about-abet/history/ [Accessed: October 30, 2022].

[7] National Academy of Engineering, "*Educating the Engineer of 2020: Adapting Engineering Education to the New Century",* Washington, DC: The National Academies Press, 2005.

[8] D. Riley, *Engineering and Social Justice,* Williston, VA: Morgan and Claypool Publishers, 2008.

[9] C. Vargas-Ordonez and M. Hynes, "Engineering design and social justice: a systematized literature review," In Proc. American Society for Engineering Education, 2020.

[10] P. Jiménez, J. Pascual, and A. Mejía, "Towards a pedagogical model of social justice in engineering education," *ICSIE*, pp. 55–59, 2019.

[11] A. Pawley, "What counts as "Engineering": Toward a redefinition", in *Engineering and Social Justice: in the university and beyond,* A. Pawley, D. Riley and C. Baillie West, Eds. Lafayette, IN: Purdue University Press, 2012, pp. 59-86.

[12] M. Cardella, C. Zoltowski, W. Oakes, "Developing human-centered design practices and perspectives through service learning" in Engineering *and Social Justice: in the university and beyond,* A. Pawley, D. Riley and C. Baillie West, Eds. Lafayette, IN: Purdue University Press, 2012, pp. 11-30.

[13] R. Roscoe, D. Becker, R. Branaghan, E. Chiou, R. Gray, S. Craig, R. Gutzwiller and N. Cooke, "Bridging Psychology and Engineering to Make Technology Work for People," *American Psychologist.* vol. 74, no. 3, pp. 394-406, 2019.

[14] A. Pawley, “Learning from small numbers: Studying ruling relations that gender and race the structure of U.S. engineering education,” *Journal of Engineering Education*, vol. 108, no. 1, pp. 13–31, 2019.

[15] S. Niles, S. Roudbari and S. Contreras, “Integrating Social Justice and Political Engagement into Engineering,” *International Journal of Engineering, Social Justice and Peace*, vol. 7, no. 1, pp. 57-69, 2020.

[16] C. Birzer and J. Hamilton, “Humanitarian engineering education fieldwork and the risk of doing more harm than good,” *Australasian Journal of Engineering Education*, vol. 24, no. 2, pp. 51-60, 2019.

[17] Prieto, J. (2013). Applying to college in the state of anxiety. *Journal of College Admission*, *221*, 69–70.

[18] Vishtak, O. V. (2004). The motivational preferences of college applicants and students. *Russian Education and Society*, *46*(8), 66–73.

[19] Scutter, S., Palmer, E., Luzeckyj, A., Burke da Silva, K. & Brinkworth, R. (2011). What do commencing undergraduate students expect from first year university? *The International Journal of the First Year in Higher Education*, *2*(1), 8–20. https://doi.org/10.5204/intjfyhe.v2i1.54

[20] Ellis, J., & Miller, P. (2014). Providing higher education in post-modern times: What do university mission statements tell us about what they believe and do? *Research in Comparative and International Education*, *9*(1), 83–91. https://doi.org/10.2304/rcie.2014.9.1.83

[21] Aib, I., & Shehzad, W. (2023). Defining mission statements in higher education: Towards a genre perspective. *Higher Education Quarterly*, *77*(1), 138–157. https://doi.org/10.1111/hequ.12378

[22] Manning, K. (2013). *Organizational theory in higher education*. Routledge.

[23] Vohra, A., Achut, H. A., Loh, A. P., & Tan, W. W. (2014). Study of motivational constructs, learning orientations and goals affecting engineering students’ learning process. *2014 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)*, 462–467. https://doi.org/10.1109/TALE.2014.7062625

[24] Stolk, J., Martello, R., Lobe, T., Taratutin, B., Chen, K. C., & Herter, R. (2012). Work in progress: En route to lifelong learning? Academic motivations, goal orientations, and learning conceptions of entering first-year engineering students. *2012 Frontiers in Education Conference Proceedings*, 1–3. https://doi.org/10.1109/FIE.2012.6462215

[25] Mamaril, N. A., Usher, E. L., Economy, D. R., & Kennedy, M. S. (2013). An examination of students’ motivation in engineering service courses. *2013 IEEE Frontiers in Education Conference (FIE)*, 1825–1827. https://doi.org/10.1109/FIE.2013.6685152

[26] Davis, S. O. (1975). A researcher’s-eye view: Women students, technical majors, and retention. *IEEE Transactions on Education*, *18*(1), 25–29. IEEE Transactions on Education. https://doi.org/10.1109/TE.1975.4320940

[27] Radziemski, C., & Mitchell, K. (2000). Different is good: Barriers to retention for women in software engineering. *30th Annual Frontiers in Education Conference. Building on A Century of Progress in Engineering Education. Conference Proceedings (IEEE Cat. No.00CH37135)*, *2*, F2F/21-F2F/24 vol.2. https://doi.org/10.1109/FIE.2000.896557

[28] DuBow, W., Kaminsky, A., & Weidler-Lewis, J. (2017). Multiple factors converge to influence women's persistence in computing: A qualitative analysis. *Computing in Science & Engineering*, *19*(3), 30–39. Computing in Science & Engineering. https://doi.org/10.1109/MCSE.2017.42

[29] Sanchez-Pena, M., Kamal, S. A., Ramirez, N., & Samuel, D. (2023). Measuring engineering culture: A preliminary approach using perceptions of meritocracy and competition. *2023 IEEE Frontiers in Education Conference (FIE)*, 1–4. https://doi.org/10.1109/FIE58773.2023.10342907

[30] Howlett, Z. M. (2021). *Meritocracy and its discontents: Anxiety and the national college entrance exam in China*. Cornell University Press.

[31] Freeman, J. B. (2020). Measuring and resolving LGBTQ disparities in STEM. *Policy Insights from the Behavioral and Brain Sciences*, *7*(2), 141–148. https://doi.org/10.1177/2372732220943232

[32] Stout, J. G., & Wright, H. M. (2015). Lesbian, Gay, Bisexual, Transgender, and Queer students' sense of belonging in computing. *2015 Research in Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, 1–5. https://doi.org/10.1109/RESPECT.2015.7296501

[33] Chavela Guerra, R. C., Farrell, S., & Longo, A. (2016). Promoting LGBTQ equality in engineering via online Safe Zone workshops. *2016 IEEE Frontiers in Education Conference (FIE)*, 1–5. https://doi.org/10.1109/FIE.2016.7757731

[34] American Society for Engineering Education. (2024).

Profiles of Engineering and Engineering Technology, 2023. Washington, DC.