

## **Studying the Impact of Humanitarian Engineering Projects on Student Professional Formation and Views of Diversity, Equity, and Inclusion**

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# **Work-in-Progress: Studying the Impact of Humanitarian Engineering Projects on Student Professional Formation and Views of Diversity, Equity, and Inclusion**

## Abstract

Though strong efforts have been made to attract women and minorities to the engineering field, diversity still lags in most disciplines. A variety of organizations and governing bodies in engineering have made calls to change this, but progress is slow. Research has shown that women and underrepresented groups continue to face barriers and challenges in the engineering workplace. This project seeks to shift the focus from simply attracting underrepresented groups to the engineering field to instead finding ways to create a more inclusive workplace culture. As inclusiveness in the workplace improves, naturally, an increase in diversity should follow as well as less barriers for women and minorities in the field. More specifically, this project hypothesizes that involvement in humanitarian engineering projects (HEP) provides unique professional formation for students, specifically with respect to their views of diversity, equity, and inclusion (DEI). The research team will examine the immediate impact of involvement (and non-involvement) in HEP on students as well as the long-term impacts using alumni responses. Data from students and alumni will be collected from a predominantly undergraduate institution with a 15-year history of completing HEP. Through questionnaires and interviews with current students and alumni, the research will explore what impacts HEP have on student professional formation around their views of DEI as well as professional responsibility. Results from this study will inform engineering education practices to create more inclusive engineering professionals with the broader impact of increased diversity in the field. This Work-in-Progress paper will detail the background and current progress of a 2-year National Science Foundation Professional Formation of Engineers: Research Initiation in Engineering Formation (NSF PFE:RIEF) project including the project framing, team formation, research training, and questionnaire development.

## Background

The engineering field has not always been welcoming of diversity despite attempts and calls by organizations to change this in recent years [1-5]. Women and non-white people have shown interest and capacity for success in engineering but often become discouraged due to unnecessary barriers in college and the professional field [1, 6-8]. Many negative factors have been reported such as stereotyping, discrimination, systemic issues, and a lack of role models [1, 2, & 9]. Companies and organizations have attempted to counteract these issues and complaints with workshops and training for the affected individuals on how to navigate these challenges. Unfortunately, these are not seen as productive solutions but rather fruitless coping strategies for underrepresented groups that do not affect real change [10 & 11]. Other efforts to improve the workplace environment such as mandatory diversity training for all employees are also ineffective [12-14]. It seems that in order to remove the barriers that discourage diversity in the engineering field that efforts could be directed at students before they enter the workforce. Improving the perspectives of the values of DEI in students could represent one significant way to change the professional engineering culture to be more inclusive. The question then is: How do engineering educators encourage an inclusive mindset in students in a largely white male field?

This project aims to study an existing program at Lipscomb University and how it has impacted student professional formation and their views of DEI. Though previously known as Lipscomb Engineering Missions (2004-2014), the Peugeot Center for Engineering Service in Developing Communities was established in 2014 within the Raymond B. Jones College of Engineering at Lipscomb. Specifically, the program provides opportunities for engineering students to complete HEP in developing communities with the support and guidance of engineering professionals and faculty. The Peugeot Center is unique in its substantial use of mentoring as well as strong, long-term relationships with partners from the communities. To date, the program has completed more than 55 projects with a focus on impactful sustainable community development alongside significant educational experience for students. Most of these projects were extracurricular but more recently HEP has been introduced to courses in the engineering curriculum at Lipscomb to support more holistic learning experiences with a real-world, complex engineering problem. The success of the program is evidenced by marked improvements in communities such as clean water, safe access via bridges, and sustainable energy systems, but also by the high level of commitment from the students and professionals involved. Of the approximately 340 alumni from the engineering college at Lipscomb, at least 155 participated in a HEP through the program during their college career. Many of these students have continued their participation in the projects as alumni serving as team leaders or technical professionals. Unlike other universities where faculty are not supported or motivated to participate in service-learning [15], Lipscomb encourages faculty participation and considers it as a valuable part of faculty development. With over 16 years of completed work, this program will supply extensive data for the research team to study a depth and breadth of experiences that may be unrivaled in the field of engineering education research. Note that the program and projects do not necessarily emphasize DEI learnings but the authors believe that the nature of the program and projects has an influence on student perceptions of DEI through HEP. If the program is found to have a positive impact on student perceptions of DEI, it would follow that the students become more inclusive engineers in the workplace. With more inclusive engineers in the workplace, underrepresented groups will encounter less barriers and challenges thus increasing diversity in the field.

A variety of research has shown that women and minorities tend to invest in and benefit from team-based involvement in service-learning. Humanitarian engineering programs and projects build on the basics of service-learning concepts but expand and deepen them to address basic human needs in the most marginalized populations. Both service-learning programs and HEP have shown marked positive impacts on student professional formation including: professional skills like teamwork and leadership [16], attitudes and identity as an engineer [17], and better recognition of global and societal contexts [18]. Studies based on effectiveness of professional skills in direct correlation with the involvement in service-learning are extensive, but tend to focus only on ABET (Accreditation Board for Engineering and Technology) criteria like teamwork, communication, and ethical responsibility. Litchfield, Javernick-Will and Maul provide a large-scale study on the benefits related to ABET criteria of service-learning in engineering on professional skills and hint toward a possible link to views on DEI [19]. While many prior studies have shown evidence of professional development due to service learning and humanitarian projects on current students, Berg, Lee and Buchanan noted the lack of measured long-term impact of these learnings and skills development. In response, the authors developed a methodology for assessing such programs in a longitudinal manner [20]. This study aims to build on these existing projects by studying the long-term impact of involvement in HEP on student professional formation.

With respect to DEI, few projects have studied direct connections between engineering curricula, activities, or programs and student perceptions of DEI. More often, engineering education researchers have focused on topics like ethics, empathy, professional responsibility, and social justice. While ethics has been heavily studied in engineering education, empathy and equity ethic are newer topics. Hess et al. describes the development of empathic perspective-taking in engineering students taking an ethics course and how this leads to socially appropriate decision-making [21]. For this research, empathy will be studied as an underlying perspective in the workplace rather than having a direct effect on clients and stakeholders. In an alternative viewpoint, McGee et al. defines the term equity ethic as a concern for helping others or desire to challenge social inequities due to exposure to social suffering [22]. Practicing social justice in engineering education has been described heavily by Leydens and Lucena in their book *Engineering Justice* [23]. Related to social justice, Canney and Bielefeldt developed an instrument to study the professional social responsibility development of engineering students [24]. More direct approaches to DEI interventions have become more common in the past few years. As such, new instruments have been developed to study the impacts of these interventions like the Valuing Diversity and Enacting Inclusion in Engineering Scale [25 & 26]. This research study aims to build from these studies and fill in the gaps by investigating the impact of student involvement in HEP on professional formation and views of DEI. The authors hypothesize that students who are involved in HEP develop stronger value for DEI and, in their future careers, will take on a professional responsibility to remove barriers and challenges for underrepresented groups in the workplace. The objective of this research study is to better understand and inform engineering education programs of the indirect benefits of involvement in HEP on underrepresented groups in the engineering field (Figure 1).

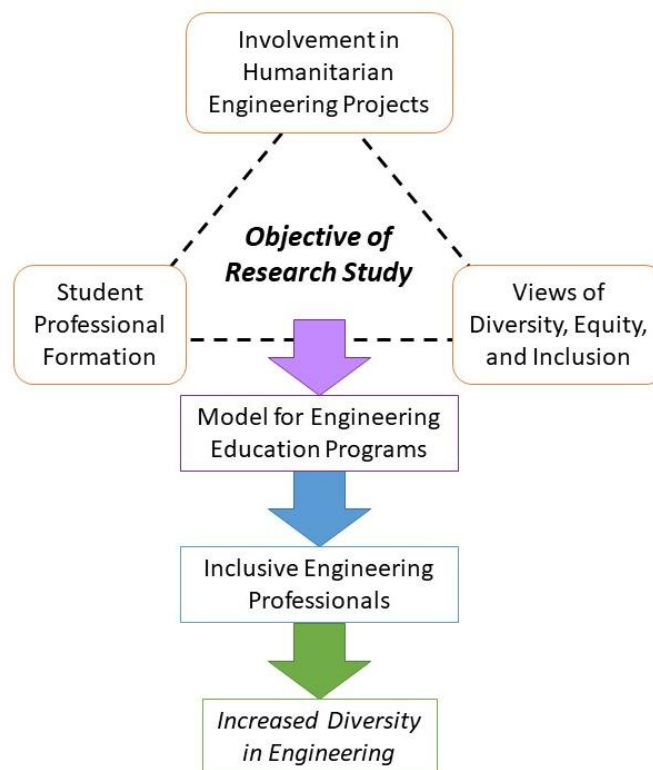


Figure 1: Examining connections between involvement in HEP, student professional formation, and views of DEI toward increased diversity in engineering.

While much of this work is built from and framed by existing literature and research, the work is also motivated by the principal investigator's (PI) own experiences with HEP and DEI. From observation and patterns noted by the PI, the study investigates the hypothesis toward a full understanding of the connections between the concepts. With this approach, the research team has chosen to keep the study open to interpretation with respect to the conceptual framework; such frameworks as case study and grounded theory have been considered. The literature reviewed, combined with the experiences of the PI, frame this project toward the following research questions and methods.

### Research Questions

This project aims to investigate the following research questions:

RQ1: What perceived impact does student involvement in HEP have on professional formation and perspectives of DEI?

RQ2: How has involvement in HEP influenced the professional workplace culture and perspectives of DEI of alumni?

While these are the primary research questions for the project, the research team is intentionally investigating these relationships between student professional formation, HEP, and DEI with flexibility. This adaptability in approach will provide space for the research team to adjust to new learnings and emergent factors as the research activities progress. Recognizing the possibility of other factors that may influence student professional formation and changes in perspectives of DEI, the team designed the research activities to isolate those factors in the questionnaire and interviews.

### Methods

The project is a sequential mixed methods study combining quantitative and qualitative aspects to examine connections between involvement in HEP, professional formation, and views of DEI. The quantitative aspect of this project will be a questionnaire which will guide the development of the interviews for the qualitative aspect. Current engineering students at Lipscomb as well as alumni of the engineering program will be asked to participate in the questionnaire and interviews. Students will reflect an immediate impact on DEI from a pre/post-questionnaire due to involvement in HEP whereas alumni will represent the long-term impacts of involvement. The questionnaires will primarily provide an introductory glimpse into the factors that relate HEP, DEI, and long-term impacts, but the interviews will provide a richer and deeper understanding of those relationships. In addition to the above, the research team is considering adding a third set of participants such as engineering professionals and/or utilizing a third method like vignettes to improve validity of the study by triangulation [27]. Adding engineering professionals as a set of participants would provide for a broader understanding of experiences with HEP outside of student experiences with the program at Lipscomb. For example, an engineering professional may have experience completing a design project for a local nonprofit organization or may have participated in Engineers Without Borders as a student, both of which would provide a comparison to the program at Lipscomb.

For the questionnaire, the research team adapted three unique instruments to study student perceptions of professional formation and perspectives of DEI. The Attitudes Toward Diversity Scale (ATDS) measures attitudes towards diversity in a workplace [28]. Though items from this scale are not used directly, the instrument inspired some of the open-ended response questions at the end of the questionnaire. The Engineering Professional Responsibility Assessment (EPRA) measures students' social responsibility attitudes and is based on the ethics of care framework by Virginia Held [24 & 29]. This instrument was created with the intention of understanding the outlook and experiences of current engineers and engineering students. It provides a glimpse into different humanitarian experiences and opportunities the respondent has participated in as well as their ratings of various aspects, skills, and job qualities in order of personal importance. Overall, the instrument takes into account personal experiences and makes inferences on the priority of the respondent's humanitarian efforts and ideals [24]. The Valuing Diversity and Enacting Inclusion in Engineering (VDEIE) scale more directly assesses the research questions by studying engineering students' values of diversity and inclusion [25 & 26]. It measures and questions the participant's intention to enact inclusive behaviors and gauges their standards of diversity and their values of inclusivity and diversity, particularly within an engineering setting. The combination of these three instruments will provide the research team with further insight into the relationship between HEP and DEI to guide the next steps of the project.

Based on feedback from authors of the three instruments and open discussion among the research team, the questionnaire was adjusted and adapted to better suit the study and participants. Demographic information will also be collected in the questionnaire including major, age, race and classification. Questions regarding the participants' involvement in HEP will be included to determine the range of depth and breadth of those experiences (i.e. a semester-long course project vs a multi-year international project). Additional open-ended response questions will probe the participants' experiences with HEP or DEI outside of the program of interest to determine if other factors should be considered in the analysis. Demographic items and questions that investigate experiences outside of the program will be useful for examining how these may have played a role in HEP involvement or views on DEI. Based on the results of the questionnaire, the research team will select participants with varied experiences with HEP and DEI to be interviewed. Researchers will recruit current students through classroom participation and via email. Alumni will be contacted based on provided information as well as through social media. Engineering professionals will be recruited through alumni networks and local professional societies. All participants will receive and sign an informed consent form prior to beginning the study. This study was deemed exempt by both Lipscomb's and Marshfield Clinic Research Institute's Institutional Review Boards (IRB).

### Project Progress and Next Steps

Since the project's start date in September 2020, the PI has built the research team, completed various trainings, and led the questionnaire design. The research team consists of the PI (an engineering professor at Lipscomb), a graduate student from the College of Education at Lipscomb, three undergraduate students from the engineering college at Lipscomb, and the mentor from Marshfield Clinic Research Institute (Figure 2). The PI is trained as an engineer thus the high level of importance for a mentor to support the development of the PI in social science and educational research. The mentor, as an established ethics education researcher, will provide expertise and training for the PI and students in social science research techniques. An external

evaluator will support the evaluation plan with formative and summative assessments and feedback on the research, training, and outreach activities. As an engineering education researcher, the external evaluator provides connection amongst the diversity of the rest of the team to the research field. The research team believes that the strong interdisciplinary nature of the team will provide unique perspectives yet constructive and rigorous evaluation of the project, training, and performance.

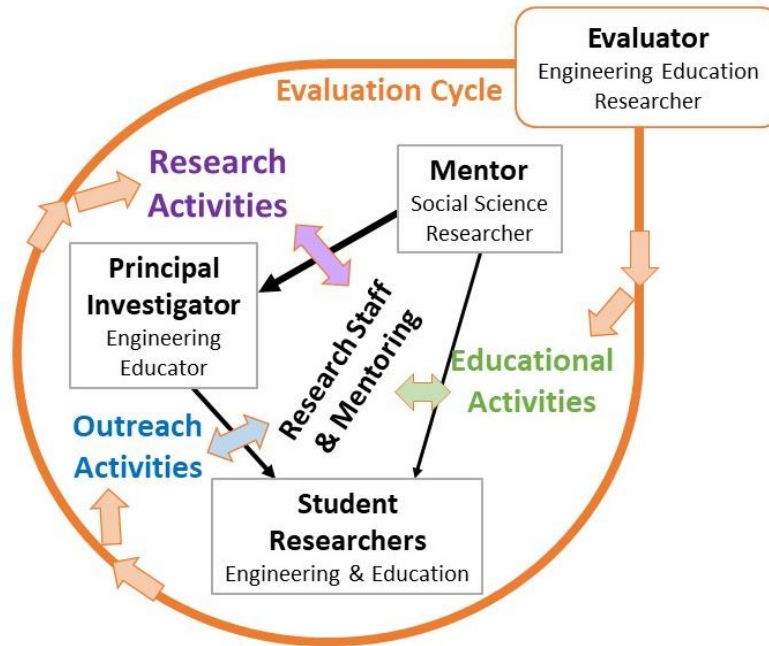


Figure 2: The team will engage in research, outreach, and educational activities that will be regularly evaluated. Black arrows indicate mentoring relationships that will be supported by these activities.

Due to the nature of the funding for the project, training was a significant part of the initial phase of the project. The PI underwent substantial training in social science, qualitative methods, and educational research techniques while the students completed basic research and ethics training through the CITI (Collaborative Institutional Training Initiatives) Program. With respect to mentoring, the mentor provided guidance to the PI on training options while the PI instructed the students in their training. With a graduate program in education on campus at Lipscomb, the PI sat in on a qualitative research methods course to prepare for the qualitative techniques required for the research study. The PI has also participated in training led by the RIEF program which allowed mentors and mentees to network and learn from one another during monthly virtual meetings. Note that because social science and qualitative research was unfamiliar for the undergraduate engineering students, the PI committed extra time in the project to provide a background for the work and how it is different from the pure scientific research that is more traditional in engineering.

Additionally, the team as a whole completed training focused on understanding DEI terminology as well as developing awareness of implicit biases. Each team member utilized the Project Implicit testing [30] to recognize their biases and become more aware of their effects. Team members were instructed to first reflect in digital journals on what their expected results would be from two Project Implicit tests: Gender-Science and Skin-Tone. After the test, the team members reflected

again in their digital journal comparing their expectations to the results. During the following team meeting, the PI led an open discussion around the team's biases and provided examples for how biases could impact the study. For example, the PI explained how an interview question could contain bias, causing the participant to feel uncomfortable and unwilling to share their experiences, and thus skew the results of the study. Similar discussions and reflections within the research team are held regularly to examine these biases and reflect on how they may impact the research. Because DEI is a significant focus for the work, the team found value in working through personal bias awareness and how it relates to DEI in the engineering field.

Recently, the research team has developed the questionnaire to retrieve data reflecting the first part of the research plan. Currently, the research team is in the process of evaluating the questionnaire and piloting it with a small set of study participants. Once feedback from the pilot is integrated, the team will finalize the questionnaire and send it out to the study participants including current students, alumni, and professionals. Results from the questionnaires will be compiled and analyzed toward the next step of the research plan, interviews. From the questionnaires, a set of participants will be selected for interviews which will investigate their experiences, perspectives, and any shifts in attitudes and behaviors due to their experiences with HEP. The research team will analyze the qualitative data through iterations of coding to find categories and patterns across student involvement in HEP, professional formation, and views of DEI. From the results of the analysis, the research team will build a model that details how HEP can be utilized effectively by engineering programs at other universities or even engineering companies (Figure 1). This model will provide clear paths for incorporating these projects into curriculum or the workplace toward creating more inclusive engineers.

As can be expected, the pandemic has brought delays to the project primarily due to canceled training and workshops and limited capacity for interaction within the research team. Nevertheless, alternatives and replacements were utilized and flexibility continues to be a key factor in project progress. Training, team discussion, and reflection were crucial in the first stages of the project and have set the team on a strong path forward. The research team, most of whom are trained as engineers rather than social science researchers, have found new life in qualitative research techniques and are excited to continue developing skills and knowledge through training and practice.

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