Creating Inclusive Engineers through Humanitarian Engineering: Quantitative Results from a Survey

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Abstract:
This paper builds on continuing research to study the impact of humanitarian engineering projects on student professional formation and views of diversity, equity, and inclusion. It is well-known that engineering lacks diversity and attempts to increase representation of women and racial minorities has not been as fruitful as hoped. The goals of this research study aim to create a more inclusive and equitable workplace environment through student involvement in humanitarian engineering projects. Thus far, the project has shown positive results through qualitative analysis of two open-ended questions from a survey [2]. The survey also employed two existing Likert-scaled instruments: the Engineering Professional Responsibility Assessment and the Valuing Diversity and Enacting Inclusion in Engineering instrument. This paper will focus on the quantitative results from these instruments in the survey from three participant groups: current engineering students at Lipscomb University, alumni of the engineering program at Lipscomb, and engineering professionals who are not affiliated with Lipscomb University. The results are compared to data from the existing instruments with a focus on connectedness and inclusive behaviors. Additionally, comparisons were made across sub-groups separated by involvement or non-involvement in humanitarian engineering projects. Interestingly, the quantitative results show significant difference from the existing instruments for the dimensions examined but little significance across the sub-groups. Data from two students who participated in the questionnaire before and after participating in a humanitarian engineering project is also presented. From these results, the authors conclude that the sampling methods may have had an impact on the mixed significance and that further qualitative methods may be appropriate for deeper study. For future work, the project team will conduct interviews with selected participants toward building a model for creating inclusive engineers through humanitarian engineering projects.

Background:
This paper details part of the work of an ongoing project previously described in [1] and [2]. The project's objective is to study the impact of humanitarian engineering projects (HEPs) on professional formation and views of diversity, equity, and inclusion (DEI). The long-term goal of the project is to develop a model to create more inclusive engineers through involvement in humanitarian engineering. The research team proposes that with more inclusive engineers, diversity of the field will then grow. This is an alternative approach from many prior efforts to increase diversity by focusing on change within the majority groups, rather than the underrepresented groups, toward inclusive and equitable practices. Humanitarian engineering is chosen as the avenue for this approach to inclusivity due to its potential for positive change on those impacted as well as those involved. As a sector of service-learning projects, other studies have shown that students involved in humanitarian engineering learn valuable technical and

professional skills and knowledge through the work [3-6]. Unique to this project, the long-term effects of involvement in humanitarian engineering projects will be studied in comparison to the more immediate effects which have been studied elsewhere. The mixed-methods study utilizes a questionnaire built from two existing instruments as well as open-ended questions and interviews to further understand these impacts. This paper will focus on the quantitative data analysis associated with the two instruments from the questionnaire whereas initial qualitative analysis has been presented in [2].

This research is built on the foundational work of many authors in engineering education literature and will be summarized here though it is expanded upon in both [1] and [2]. Related to humanitarian engineering and service-learning, Litchfield, Javernick-Will, and Maul studied the benefits of involvement in these types of projects as they related to ABET (Accreditation Board for Engineering and Technology) criteria [3]. Huff, Zoltowski, and Oakes focused their work on EPICS (Engineering Projects in Community Service) alumni to understand how their involvement impacted their teamwork and leadership skills [4]. Bielefeldt, Paterson, and Swan noted in their study that project-based service learning provided an added component around attitude and identity development compared to simple project-based learning [5]. Lastly, Berg, Lee, and Buchanan took steps toward studying the long-term impact on student involvement in humanitarian engineering and developed a methodology for program evaluation [6].

Where humanitarian engineering is the avenue for this research study, the attitudes, behaviors, beliefs, and views of participants are the focus of the project. The questionnaire for the project was built to specifically study professional responsibility and views of diversity and inclusion in engineers and engineering students. The two instruments include the Engineering Professional Responsibility Assessment (EPRA) and the Valuing Diversity and Enacting Inclusion in Engineering (VDEIE) scale. The EPRA was chosen to measure participants' views of professional and social responsibility [7]. The VDEIE on the other hand was chosen to measure participants' attitudes and beliefs around diversity and inclusion [8]. Combined, these instruments provide a glimpse into the perspectives related to the objective of this research and a primary question the researchers hope to answer: do students involved in HEPs feel a sense of responsibility to enact inclusive behaviors? Alongside the instruments, a few open-ended questions were included to provide richer information than the Likert scaled items allow. The open-ended questions uncovered much more nuanced attitudes and beliefs around concepts like empathy and identity development - ideas supported by other foundational engineering education literature. Walther, Miller, and Sochacka describe empathy in engineering as a professional way of being [9] whereas Huff et al. discusses the importance of identity development in early career engineers [10]. Initial findings from the open-ended questions from the questionnaire from thematic analysis of the responses are analyzed fully in [2].

Though not necessarily foundational to this work, the authors find inspiration from three other studies with similar objectives. First, Cech discusses an idea that beliefs of professional work can impact intra-profession activities in the workplace [11]. Cech reflects that the engineering ideology of technical/social dualism may have a role in the gender wage gap in the field. In relation to this study, could involvement in HEPs cause students to reconsider their ideological separation of technical and social concepts thus reducing inequality in the field? Similarly, McGee and Bentley describe a desire in black and Latinx STEM students to practice equity and justice within and outside their career and coined this concept as 'equity ethic' [12]. Interestingly, Swan, Paterson, and Bielefeldt suggest that women and minorities tend to invest in and benefit from involvement in service-learning in engineering due to their potential for social impact [13]. Is it possible that student involvement in HEPs could create an equity ethic which leads to more inclusive practices in their career? Lastly, Reynante details a connection between student involvement in community engagement, a field closely related to humanitarian engineering, and empathy development toward justice [14]. Using a case study as the methodological approach, Reynante illustrates some of the characteristics and learning processes required for students to shift from a 'design-for-charity' mindset to 'design-for-justice'. Connecting to this study, the humanitarian engineering program under investigation practices many of these 'design-for-justice' approaches already, some of which are described in [15]. Building from these works, this project intends to further investigate the connections between humanitarian engineering, professional formation, and views of diversity, equity, and inclusion.

Methodology:

The project employs a mixed-method approach through a questionnaire and interviews across three different participant groups. The quantitative data analysis of the questionnaire will be the focus of this paper. The research questions are as follows:

- What perceived impact does student involvement in HEPs have on professional formation and perspectives of DEI?
- How has involvement in HEPs influenced the professional workplace culture and perspectives of DEI of alumni?

As stated previously, two instruments were used to build the questionnaire, the EPRA and VDEIE. Both use 7-point Likert scales across 43 and 17 items, respectively, for a total of 60 questions in the survey. Twelve items were removed from the EPRA instrument (originally 50 items) based on discussions with the author of [7] as an attempt to reduce the length of the questionnaire, including four items from the Professional Connectedness dimension, three from Cost-Benefits, and five from Awareness. Note that the original EPRA survey from [20] included 4 extra items that were not included in [7] but that the research team decided to include in this study due to their relevance. A check item was also used which asked participants to mark a specific response ('slightly disagree') to ensure attention. Three open-ended questions were also included but the analysis is presented separately in [2]. Demographic questions were also

included which covered race/ethnicity, gender, age, occupation/student status, first generation, religion, and involvement in humanitarian engineering or service projects. The survey was built in Google Forms with consent included prior to the instruments. The study was deemed exempt by the Lipscomb Institutional Research Board. The participants were sorted into three groups:

- Current students of Lipscomb engineering program
- Alumni of Lipscomb engineering program
- Engineering professionals who are not alumni of Lipscomb

Each participant group provides a unique perspective to support the investigation of the research questions. Current students provide a glimpse into the immediate impact of involvement in a HEP as well as the contrasting experience of students who do not participate in a project. Alumni contribute a long-term perspective of the impact of involvement in a HEP on their professional formation in their careers. The humanitarian engineering program, also known as the Peugeot Center, at Lipscomb University has nearly 20 years of history providing for a wealth of alumni with experiences stemming from those projects. The program is well-known for its substantial impact on the communities it works with and its holistic approach to projects which is documented in [15]. Most students who participate in Peugeot Center projects do so as an extracurricular activity though some projects are now integrated into coursework. Projects through the Peugeot Center which are included in courses tend to be smaller, local efforts such as building a micro-home for transitional housing or designing a biomedical waste incinerator for a rural medical clinic. Extracurricular projects through the Peugeot Center tend to be infrastructure-type international projects (i.e., clean water systems or solar panel installation for a hospital) requiring substantial design and construction efforts with students participating for a single year or multiple years depending on their commitment. Because most of the projects are outside of class, it's possible that students with higher social responsibility tend to self-select into these projects. Note that any students involved with extracurricular Peugeot Center projects complete significant training around culture, ethics, teamwork, and communication in preparation for the travel alongside the project work itself but there is no specific emphasis on DEI. More details of the Peugeot Center and the HEPs completed through this program can be found in [15].

Engineering professionals who are not alumni allow for a varied perspective outside of Lipscomb's engineering program. Note that a large proportion of the surveyed non-alumni engineering professionals participated in a HEP during their professional career which is likely higher than the norm within the field. This is likely due to the recruitment method as most of the engineering professionals were recruited for the questionnaire during an engineering service conference. Approximately 200 engineering professionals had access to the questionnaire during the conference. Students were recruited to participate in the questionnaire by email and announcements during class periods (about 80 invited to participate) whereas alumni were recruited through a Facebook group and LinkedIn post. The student participants were a mix of

civil, electrical and computer, and mechanical engineering majors which are all offered at Lipscomb University. These participant groups will be named students, alumni, and professionals for the simplicity of this paper. Table 1 provides a summary of the participants by demographics.

Table 1: The self-identified demographic representation of participants including gender and race is shown as percentages of the total of each group.

	Students	***Alumni***	***Professionals***	***Total***
Number	39	19	40	98
Men	82%	79%	73%	78%
Women	18%	21%	25%	21%
Prefer not to say	-	-	3%	1%
White	67%	84%	73%	72%
URM	13%	16%	5%	14%
Other	15%	0%	20%	10%
Prefer not to say	5%	-	3%	3%
1st Generation	23%	11%	28%	22%
Importance of Religion	3.47	3.67	3.53	3.53
Participated in HEP	23%	95%	83%	61%

Note that *URM* in Table 1 reflects underrepresented minorities in the engineering field and includes black or African American, Hispanic or Latino, and American Indian or Alaska Native as defined by [16]. The authors of this paper recognize the problematic language with the label underrepresented minorities (URM) as commented on by Williams and would prefer to separate these identities but due to the low numbers of responses must balance the privacy and protection of the survey participants [17]. Whereas *Other* reflects participants who identified as something other than white or URM. While those who are categorized as *Other* by race may identify as racial minorities by population, their race is not considered an underrepresented group in engineering and thus are separated from the URM and white categories. The authors of this paper recognize that while those in the *Other* category may not be underrepresented in the engineering field, they may have experienced discrimination or bias in the workplace because of their race or ethnicity which is in direct contrast to the focus of this study on DEI. The goal of this project is to increase inclusivity for everyone in engineering, regardless of how they identify, and decrease discrimination and bias in the field. The authors recognize that there are limits to this study as a variety of other identifiers were not included in the survey.

Participants were also asked if they were the first generation of their family to attend college. The importance of religion was also reported on a 4-point scale (4 - Very Important, 3 - Somewhat Important, 2 - Not too Important, 1 - Not at all Important) with the average shown in the table. Participants were also asked to identify community service activities where involvement in humanitarian engineering projects (HEP) was an option. Selections for the community service activities were included from the EPRA with a few additional options to

cover HEPs [7, 19]. The types of HEPs completed are discussed further in the Conclusions. Not included in the above table are the second responses from two student participants who completed the questionnaire before and after they had participated in an HEP. Their initial response to the demographic questions is included in Table 1 whereas a comparison of their pre- and post-involvement responses will be analyzed in the Results.

As shown in Table 1, the race and gender profiles across all three participant groups are fairly typical of the engineering field. Based on recent data (2021) published by the National Center for Science and Engineering Statistics, 16% of employed engineers identify as female and about 30.7% identify as a race other than white [18]. Similarly, from ASEE's *Profiles of Engineering and Engineering Technology*, Bachelor's degrees awarded to women averaged about 24% in 2022 and URM averaged 16.5% [19]. Interestingly, the demographic data that is most surprising is the high number of participants who have been involved in a HEP from the alumni group at 95%. It's possible that participation in the research study was simply attractive to alumni who have been involved in a HEP simply due to its relevance to their experience.

Results:

Following data collection, names and identifiers were removed and the responses were sorted for analysis and comparison. The results are organized as shown:

- Tables 2 and 3: Presentation of means and standard deviations for the original EPRA and VDEIE as well as the three participant groups
- Table 4 and 5: Statistical comparison to the original EPRA and VDEIE population data for each participant group
- Tables 6 and 7: Statistical comparison across those who participated in a HEP compared to those who have not for each participant group
- Table 8: Pre- and post-comparison for two students who completed the questionnaire before and after participation in a HEP

Note that the comparisons for Tables 4-8 focus on two dimensions from the EPRA, Connectedness and Professional connectedness. Connectedness from the Personal social awareness realm is defined as "A feeling of moral obligation, responsibility, or social requirement to help others" whereas Professional connectedness from the Professional connectedness realm is defined as "Addresses issues of responsibility or obligation that an engineer or the engineering profession may have to help solve social problems or help others through their professional capacity [7]." From the VDEIE, one construct, Inclusive Behaviors, with two factors, Challenge Discriminatory Behaviors and Promote Healthy Work Environment, was included for comparisons. The combination of these four dimensions aligned closely with the aims of this research study to investigate how involvement in HEP influences engineers to create inclusive work environments.

Data Presentation:

First, the data from each group of participants was averaged and compared to the respective original instrument by dimension (EPRA) or construct and factor (VDEIE). From here, the research team searched for statistically significant differences between this study and the original instruments. The data for comparison to the EPRA instrument is from [7] whereas the VDEIE instrument is from [8]. The EPRA population included 1000 engineering students from five universities across first-year to graduate levels, mostly in civil, environmental, or mechanical fields. The VDEIE population included 267 students from a large public university who were enrolled in an introductory class in mechanical, civil and environmental, or general engineering. Though this paper covers a broader sample and includes alumni and professionals, the focus of the research study is on the impact to students thus these populations are used for comparison purposes.

Table 2 shows data for each group of participants alongside the EPRA population and Table 3 shows the same with the VDEIE population. The ordinal alpha (α) for the ERPA dimensions is included alongside the means and standard deviations to demonstrate the internal reliability across the items for each dimension [7]. The reliability (r) is also shown for the VDEIE constructs and factors [8].

Table 2: Sample data from the three participant groups compared to data from the EPRA instrument. *4 items and **3 items removed from the original instrument, respectively.

		Population			***Study Sample***					
Dimension	**No. of Items**	**EPRA**			**Students**		**Alumni**		**Professionals**	
		M	SD	α	M	SD	M	SD	M	SD
Ability	4	5.57	0.76	0.835	5.75	0.89	5.97	0.78	5.96	0.69
Connectedness	4	5.33	0.97	0.859	5.68	0.90	6.00	0.63	6.19	0.71
Base Skills	5	6.28	0.73	0.729	6.18	0.57	6.14	0.71	5.91	1.25
Professional ability	4	6.39	0.57	0.737	6.37	0.55	6.53	0.66	6.27	0.58
Analyze	5	5.63	0.75	0.732	5.75	0.73	5.80	0.80	5.97	0.72
Prof connectedness	15*	5.12	0.84	0.930	5.36	0.64	5.69	0.67	5.94	0.55
Costs-benefits	1**	5.32	0.95	0.813	5.87	0.80	6.42	0.84	6.18	0.98

Table 3: Sample data from the three participant groups compared to data from the VDEIE instrument.

			Population			***Study Sample***					
Construct	**Factor**	**No. of Items**	**VDEIE**			**Students**		**Alumni**		**Professionals**	
			M	SD	r	M	SD	M	SD	M	SD
Valuing Diversity	Fulfill Greater Purpose	4	5.82	1.07	0.90	5.58	0.99	5.53	1.22	5.78	0.94
	Serve Customer Better	4	6.05	0.83	0.81	5.94	0.79	6.14	0.85	6.20	0.67
Inclusive Behaviors	Challenge Discr Behavior	5	5.50	1.19	0.89	5.83	1.33	5.79	0.75	6.10	0.69
	Promote Healthy Env	4	6.14	0.64	0.90	6.54	0.62	6.51	0.44	6.36	0.60

Comparison 1: Original Instruments

To perform comparisons, each group was checked for a normal distribution by calculating skewness and kurtosis for the chosen dimensions. If these were within the acceptable ranges (-1 to 1 for skewness) and (-2 to 2 for kurtosis), the sample groups were considered to have a fairly normal distribution and a z-test was used to compare the sample mean to the EPRA and VDEIE population means and standard deviations. From the z-tests, two-tailed p-values were calculated and compared to an alpha of 0.05. Only one set of data, Students in Table 5, was found to not have a normal distribution so a Sign test was used for comparison for this case and the Z-score was calculated from the p-value, which was also compared to an alpha of 0.05. The data below shows that all participant groups showed some significant difference as compared to the EPRA and VDEIE dimensions. The Cohen's d value is also calculated for each group and dimension to show the effect size. Students showed fairly small differences for the Connectedness dimensions compared to the EPRA, but the alumni and professionals showed large differences for these dimensions. The results for the Inclusive Behaviors construct varied for each group and across the two factors but showed at least small differences to the VDEIE population data.

Table 4: Statistical comparison of each participant group to two dimensions within the EPRA instrument. Bolded and italicized p values indicate significant difference to the EPRA data.

Students	Skew	Kurt	z	p	Cohen's d
Connectedness	-0.76	0.30	2.250	***0.0244***	0.374
Prof connectedness	0.14	0.54	1.751	0.0799	0.321

Alumni	Skew	Kurt	z	p	Cohen's d
Connectedness	-0.07	-0.68	3.011	***0.0026***	0.819
Prof connectedness	-0.08	-1.26	2.964	***0.0031***	0.750

Professionals	Skew	Kurt	z	p	Cohen's d
Connectedness	-0.59	-0.61	5.591	***<0.0001***	1.011
Prof connectedness	-0.26	-0.62	6.199	***<0.0001***	1.155

Table 5: Statistical comparison of each participant group to two factors within the VDEIE instrument. Bolded and italicized p values indicate significant difference to the VDEIE data. Italicized skewness and kurtosis (Students) indicate non-normal distribution where a Sign test (Z*) was used for comparison.

Students	Skew	Kurt	Z*	p	Cohen's d
Challenge Discr Behavior	*-1.77*	*3.58*	2.931	***0.0034***	0.262
Promote Healthy Env	*-1.49*	*2.05*	3.273	***0.0011***	0.635

Alumni	Skew	Kurt	z	p	Cohen's d
Challenge Discr Behavior	-0.03	-0.93	1.060	0.289	0.292
Promote Healthy Env	-0.44	-1.16	2.542	***0.011***	0.674

Professionals	Skew	Kurt	z	p	Cohen's d
Challenge Discr Behavior	-0.66	0.13	3.189	***0.0015***	0.617
Promote Healthy Env	-0.77	0.59	2.199	***0.0279***	0.355

Comparison 2: By involvement in HEP

For the second comparison, participant groups were sorted into sub-groups based on whether they had participated in a HEP at the time of the survey. Example HEP responses in the survey included but are not limited to: Engineers without Borders (EWB), Engineers for a Sustainable World (ESW), short-term HEP, long-term HEP, Engineering Ministries International (EMI), and Peugeot Center project through Lipscomb's engineering program. Students tended to respond with short-term HEPs or service-learning projects in courses. Alumni mostly responded with involvement in HEPs through the Peugeot Center at Lipscomb University which are generally extracurricular and include significant project work and short-term travel. Only one alumnus had not participated in a HEP at the time of the questionnaire thus limiting the comparison for that group. Professionals' responses varied more widely and included short-term HEPs, long-term HEPs, and involvements with organizations like EWB and EMI.

The means and variances are shown in the table alongside results from two sample *t* tests. The ratio of variances for each comparison was found to be less than 4 thus equal variances were assumed for the t-test. From the t-tests, t-stat values were found as well as two-tail p values to determine if there was statistically significant difference between the means of the sub-groups. Again, an alpha of 0.05 was used to test for significance. Interestingly, no significant difference was found across the sub-groups within each participant group for any of the dimensions studied. The results compared across these sub-groups of HEP and no-HEP are shown in Tables 6 and 7.

Table 6: Sample data from the three participant groups sorted by if they have (HEP) or have not (no-HEP) participated in a HEP prior to the survey compared to data from the EPRA instrument. The number of each sub-group is included with their involvement or non-involvement in HEP.

Students	**HEP (9)**		**no-HEP (30)**		**t-test: Two Sample, Equal Variances**	
	M	Var	M	Var	t-stat	p (two tail)
Connectedness	6.00	0.70	5.58	0.83	1.222	0.230
Prof connectedness	5.55	0.17	5.30	0.48	1.026	0.312

Alumni	**HEP (18)**		**no-HEP (1)**	
	M	Var	M	Var
Connectedness	6.00	0.42	6.00	--
Prof connectedness	5.74	0.43	4.87	--

Professionals	**HEP (33)**		**no-HEP (7)**		**t-test: Two Sample, Equal Variances**	
	M	Var	M	Var	t-stat	p (two tail)
Connectedness	6.19	0.48	6.18	0.72	0.036	0.971
Prof connectedness	5.94	0.22	5.96	0.76	-0.098	0.923

Table 7: Sample data from the three participant groups sorted by if they have (HEP) or have not (no-HEP) participated in a HEP prior to the survey compared to data from the VDEIE instrument. The number of each sub-group is included with their involvement or non-involvement in HEP.

Students	**HEP (9)**		**no-HEP (30)**		**t-test: Two Sample, Equal Variances**	
	M	Var	M	Var	t-stat	p (two tail)
Challenge Discr Behavior	6.04	0.87	5.76	2.05	0.559	0.580
Promote Healthy Env	6.42	0.28	6.58	0.42	-0.668	0.508

Alumni	**HEP (18)**		**no-HEP (1)**	
	M	Var	M	Var
Challenge Discr Behavior	5.72	0.50	7.00	--
Promote Healthy Env	6.56	0.17	5.75	--

Professionals	**HEP (33)**		**no-HEP (7)**		**t-test: Two Sample, Equal Variances**	
	M	Var	M	Var	t-stat	p (two tail)
Challenge Discr Behavior	6.05	0.51	6.34	0.34	-1.022	0.313
Promote Healthy Env	6.35	0.38	6.43	0.26	-0.319	0.751

Comparison 3: Pre- & Post-HEP

Following the initial collection of data from students, the research team followed up with the participants to request a second response to the survey following their involvement in a HEP.

Of the 39 students that responded in the initial data collection cycle, 9 had already participated in a HEP and 5 participated in a HEP in the year following their response. From those 5 that had not participated a HEP during their first response and then participated in a HEP during the following year, two students responded for a pre- and post-HEP comparison. Their pre-HEP and post-HEP responses (S17 and S34) are shown in Table 8 for the four dimensions. Note that no statistical analysis was performed for these results but will be investigated in future work.

Table 8: Pre- and post-comparison of two students who participated in a HEP across two dimensions from the EPRA and two factors from the VDEIE.

EPRA Dimension	**S17**		**S34**	
	pre	post	pre	post
Connectedness	5.75	5.75	4.25	5.50
Prof connectedness	5.33	5.13	4.53	6.73

VDEIE Factor	**S17**		**S34**	
	pre	post	pre	post
Challenge Discr Behavior	3.00	2.40	7.00	7.00
Promote Healthy Env	6.00	5.00	7.00	7.00

Though preliminary, a simple review of the pre- and post-HEP results showed a general increase in connectedness from the EPRA dimensions for one student (S34), but a decrease in inclusive behaviors from the VDEIE factors for the other (S17). The initial high scoring of S34 on inclusive behaviors may have created a ceiling thus limiting the potential for an increase. It's possible that the type of HEP could have impacted these students' experiences. S17 participated in a project through Lipscomb which included a site visit to an international location for bridge surveying whereas S34 participated in a course-based HEP to build a micro-home (with support of the Peugeot Center) with only short local travel involved. Though S17 participated in international travel, the site visit likely lacked significant hands-on design or construction. In contrast, S34 participated in a local project with heavy hands-on design and construction as well as full delivery of the micro-home. The results for these two students alongside the comparison of their experience with HEPs seem to contrast with research that has shown little impact of service on intercultural development [21]. Oddly, these students seem to have been impacted by their service experience, but in opposite ways. Note that intercultural development tends to refer to international cultural differences whereas this study is focused on workplace culture though the topics are similar. These varied experiences and responses provide a glimpse into how students' experiences with humanitarian engineering projects can be quite dissimilar. The research team hopes that further qualitative data collection through interviews will provide new insights.

With only quantitative data from the questionnaire, it is difficult to draw full conclusions from the limited information given. To better support some of these conclusions, a few quotes from the open-ended questions are given below from Student 17 who seemed to have the more surprising results from the quantitative data based on Table 8. For the question *If provided the opportunity, would you participate in a humanitarian engineering project in the future? Why or why not?*, the student responded*:*

> S17 Pre-HEP: "Yes because I feel like it would not only have a real impact on people's lives, but it would be a lot of fun."
> S17 Post-HEP: "Yes because it is a great way to use my engineering skills to serve others"

For Student 17, though there was a lack of change in the quantitative responses, it seems that the student did increase recognition that engineering can have an impact. Student 17 also had an interesting response to the question *Briefly describe an event that has influenced your views of diversity, equity, and inclusion*. Note that this open-ended question immediately followed the VDEIE items in the survey:

> S17 Pre-HEP: "My uncle is from Honduras so I have heard stories from how he has been treated at times here in the US."
> S17 Post-HEP: "I grew up in a very diverse school… Unfortunately, I feel like I don't speak up when I hear racist or sexist comments because I don't like to argue with people."

The student's response prior to participation in a HEP shows some recognition of discrimination with respect to race and ethnicity but no mention of personal responsibility to act or behave in an inclusive way. The post-HEP response shows a recognition of diversity and that there should be some action or behavior to challenge discrimination, but the student's personal desire restricts them from enacting those behaviors. Student 17's comments provide an interesting perspective that the researchers hope to investigate further through interview: that recognition and awareness of DEI values does not always translate into action and behavior. Qualitative methods may be better suited to understanding this hurdle from awareness to action including what causes the hurdle and how to overcome it.

<u>Conclusions and Next Steps:</u>

Overall, the three participant (sample) groups showed statistically significant differences from the EPRA and VDEIE populations but interestingly showed little to no differences across the sub-groups who were or were not involved in a HEP prior to the questionnaire. Based on these results, the authors conclude that all participants in the questionnaire displayed higher scores, to varying degrees, to the four dimensions studied and there was little impact from involvement in

HEP. Larger differences were found for alumni and professionals compared to the ERPA dimensions whereas students displayed smaller differences (Table 4). A mix of small to medium differences were found for the three groups across the two VDEIE factors as shown by the Cohen d values in Table 5. Unfortunately, due to the lack of responses from alumni who had not participated in HEP, data could not be analyzed for these sub-groups. This limitation is considerable as the alumni from Lipscomb engineering program with HEP experience would have provided significant information about the long-term impacts of HEP on inclusive behaviors in the workplace. Additionally, it's possible that a quantitative method does not adequately address the nuanced ideas and perspectives that the team had hoped to unveil. The team predicts that interviews with selected individuals, especially from the alumni group as well as the two students with pre- and post-HEP responses, will provide for a much more colorful and thorough picture in reflection of the study goals.

As mentioned earlier, it's possible that those who participate in HEP self-select into involvement due to higher levels of professional responsibility or desires to practice justice or equity. Based on the results from this survey, there is not a clear distinction between those who have or have not participated in HEP with respect to connectedness or inclusive behaviors. Though there is not a clear distinction based on this quantitative data, the qualitative data from the open-ended questions as well as interviews could lead to a deeper understanding of this correlation. Note that the open-ended questions were analyzed from alumni and these results are published in [2].

The research team recognizes some of the limitations to this study, but also sees a couple of these as opportunities for future work. First, the EPRA and VDEIE studied students only whereas this project includes participant groups who have been actively working in the field of engineering. Though this causes question of relevance for comparison of the data, this survey presents new and unique sample data for these instruments that might be useful for other researchers. Though the type of HEP was categorized in the questionnaire, it is unlikely that one respondent's experience was exactly like another's for the same selected HEP. Experiences vary greatly across these types of projects thus it is difficult to examine those differences in a quantitative method. Note that the small sample size of each participant group limits comparison of sub-groups, especially across demographic subgroups like women or racial minorities. The length of time to complete the survey, estimated at 15-20 minutes, may have decreased participation even though there was an incentive of a $100 gift card drawing. Lastly, though the EPRA and VDEIE instruments align closely with the objectives of this project, they examine separate and distinct topics. The objective of the project is examining complex perspectives and experiences that may not be adequately investigated through Likert-scale items. These perspectives and experiences are more suited to a qualitative study which is the next step in this project.

As part of the mixed methods research, the research team will utilize responses from the survey to select participants. The survey responses will also inform the interview design with the goal of

retrieving the most thorough and rich data to guide the final stage of the project. From the interviews, the research team will perform an analysis with the purpose of developing a model. This model will provide educators and engineering companies or organizations with the tools and guidelines to create inclusive engineers through humanitarian engineering projects.

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