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Creating Inclusive Engineers through Humanitarian Engineering Projects: Path Modeling toward Professional Responsibility and Inclusive Behaviors

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Abstract:

This empirical research brief builds on previous work to better understand how involvement in humanitarian engineering projects (HEPs) can impact a participant's professional responsibility and inclusive behaviors. Research in this field has already shown connections between professional responsibility and HEPs, but little research has been done to connect these to inclusive behaviors. This project theorizes that HEPs can expose participants to new people and perspectives providing a space to learn and practice equity and inclusivity while creating positive impact. So far, this research has uncovered correlations between professional responsibility and inclusive behaviors as well as some differences among those who have and have not participated in a HEP. This paper describes regression analysis performed on the data to investigate path models between these factors. Data was collected using a survey including two validated instruments: the Engineering Professional Responsibility Assessment (EPRA) and the Valuing Diversity and Enacting Inclusion in Engineering (VDEIE). Two factors from each instrument were chosen for further analysis based on their relevance and insight to the research objective: professional connectedness (PC) and personal connectedness (CO) from the EPRA as well as challenging discrimination (CD) and promoting a healthy work environment (PH) from the VDEIE. Three participant groups were included: current engineering students of Lipscomb University, alumni of Lipscomb engineering, and professional engineers not affiliated with Lipscomb. Demographic data and information about HEP participation was also collected. This paper will describe the proposed theoretical model, the associated path analysis, and the resulting relationships. Direct and indirect relationships as well as path strengths were investigated to finalize the relational model between HEP involvement, professional responsibility, and inclusive behaviors. From this analysis, the authors found that participation in HEPs can predict professional responsibility which then predicts inclusive behaviors. Interestingly, HEP involvement does not predict inclusive behaviors directly but rather indirectly through professional responsibility. Further, inclusive behaviors do not predict involvement in HEPs. This suggests that participation in HEPs can create inclusive engineers indirectly through improving professional responsibility. Other relationships are proposed and suggested based on thematic analysis from interviews but are not formally included in the path analysis. Future work could expand this model with cohorts outside of Lipscomb University to investigate generalizability to broader contexts.

Keywords: path modeling, regression analysis, humanitarian engineering, professional responsibility, diversity equity and inclusion

Background:

This study is a continuation of a project focused on understanding the influence of student participation in humanitarian engineering projects (HEPs) on professional formation and views of diversity, equity, and inclusion (DEI). The authors propose that involvement in HEPs can create more inclusive engineers that build a better workplace environment in engineering. Humanitarian engineering describes the design and/or implementation of projects or solutions focused on addressing basic needs such as clean water, safe

shelter, or access to energy. A variety of exemplary university-based humanitarian engineering programs are detailed in [1] though professional organizations also exist to support these efforts. Studies of these programs have shown the positive impacts of HEP involvement in professional skills [2, 3] as well as some social qualities [4, 5]. The project detailed here studies the impact of student involvement in HEPs on both professional and social dimensions, specifically professional responsibility and inclusive behaviors. Other studies have suggested connections between some of these parameters, but this study is the first to propose causal relationships based on path modeling and analysis.

The full study performed a mixed method research design using a survey for quantitative analysis and interviews for qualitative. The survey was built from two existing and validated instruments: the Engineering Professional Responsibility Assessment (EPRA) [6] and the Valuing Diversity and Enacting Inclusion in Engineering (VDEIE) scale [7]. From an initial quantitative analysis of the survey data, some differences were found between participation groups - professionals showed more obligation to help others than students. Interestingly, the research team found that those who participate in HEPs did not self-select into these activities based on higher levels of professional responsibility or inclusive behaviors [8]. Without significant results from the quantitative portion of the study, the team developed an interview protocol based on the survey results to better understand the complex connections between these dimensions of professional responsibility and inclusive behaviors. Qualitative results from the semi-structured interviews pointed toward connections between feeling a sense of 'purpose' through the HEPs as influential to building relationships. The HEPs uniquely provided the opportunity to build relationships within the team or with communities or partners which then helped students develop inclusive behaviors that were carried into school or their workplace [9]. Based on these results, further quantitative analysis was performed to study correlations between these factors. This analysis is detailed in [10] but showed significant differences in the ways students and professionals practice professional responsibility and inclusive behaviors as well as differences between those who have and have not participated in HEPs. The results from the correlation analysis led to a desire to understand more about potential causal relationships between these factors, thus the focus on path modeling and analysis for this empirical research brief.

Objective:

The larger study is focused on understanding connections between involvement in HEPs, feelings of professional responsibility, and views of DEI. Results from these analyses have contributed to the creation of a preliminary model and framework that describes how HEPs create inclusive engineers as well as how to design HEPs such that they achieve that objective [11]. The path modeling presented here further supports the model and framework by better describing the relationships between these dimensions. The research questions associated with the larger study are:

- RQ1: What perceived impact does student involvement in HEPs have on professional formation and perspectives of DEI?
- RQ2: How has involvement in HEPs influenced the professional workplace culture and perspectives of DEI of alumni?

Thus the path modeling and analysis attempt to provide more concrete evidence to answer RQ2 with supporting validation from the interviews. Results from the path analysis will be utilized to further refine the model and framework for creating inclusive engineers through HEPs.

Methods:

From the two instruments, four factors (Likert-scale items) were chosen for the correlation analysis and the path modeling:

- *EPRA - Connectedness (CO):* moral obligation to help others
- *EPRA - Professional Connectedness (PC)*: professional responsibility to help others
- *VDEIE - Challenge Discriminatory Behavior (CD)*
- *VDEIE - Promote a Healthy Work Environment (PH)*

Demographic data was also collected including the participants' involvement in HEPs. For each participant, this parameter was assigned a 0 or 1 for involvement or no involvement in a HEP respectively. This parameter, HEP involvement, plus the four factors above provided five parameters for the path modeling (Figure 1). Current students and alumni of Lipscomb University's engineering program were invited to complete the survey as well as engineering professionals who are not alumni to provide an alternative perspective of the impact of HEP through other programs. Many of the students and alumni participated in HEPs through the Peugeot Center which is described in more detail in [12] including a program model and project case study. In total, the path modeling and analysis includes 98 respondents across the three participant groups (39 students, 19 alumni, and 40 professionals) with 61% participation in HEPs. The study was deemed exempt from full review by Lipscomb's Institutional Review Board.

Prior to analysis, each parameter was checked for normal distribution using skewness and kurtosis with acceptable ranges of -1 to 1 and -2 to 2 respectively. Four were considered to have a normal distribution, but there was a clear outlier in the *Challenge Discriminatory Behavior* parameter causing a non-normal distribution. For this respondent, the other three Likert-scaled items were within one standard deviation of the mean, except for this parameter summarized as a 1.0 compared to the average of 5.93. Interestingly, for this respondent, the other parameter from the VDEIE scale (*Promote a Healthy Work Environment)* was summarized as a 7.0 compared to the average of 6.46. Without further understanding of this response behavior, this observation is seen as a significant outlier either due to respondent error (mistook direction of Likert-scale) or extreme biases around discrimination. Because this outlier largely skewed the dataset, the authors chose to Winsorize the value and replace it with the next lowest value of 3.0 [13]. With the influence of this outlier minimized, the remaining parameter of *Challenge Discriminatory Behavior* was found to fit a normal distribution alongside the other four parameters.

Results:

Prior to path modeling, the authors performed a correlation analysis of all five parameters and determined the significance of each to limit the relationships studied. Significance of the correlation was compared to the critical t value for 98 participants. Insignificant correlations were set aside unless further analysis warranted investigation. The results of this analysis are shown in Figure 1. To simplify matters, involvement in HEPs serves as the independent variable from which others are dependent as this is the

proposed initiator of any behavioral changes. It was also assumed that the inclusive behaviors were the result of other variables though this was confirmed through model testing.

Five Factor Correlation Analysis

n=98	*CO*	*PC*	*CD*	*PH*	*HEP*
CO	1				
PC	***0.679***	1			
CD	***0.233***	***0.286***	1		
PH	0.134	0.187	***0.222***	1	
HEP	***0.243***	***0.305***	0.024	-0.089	1

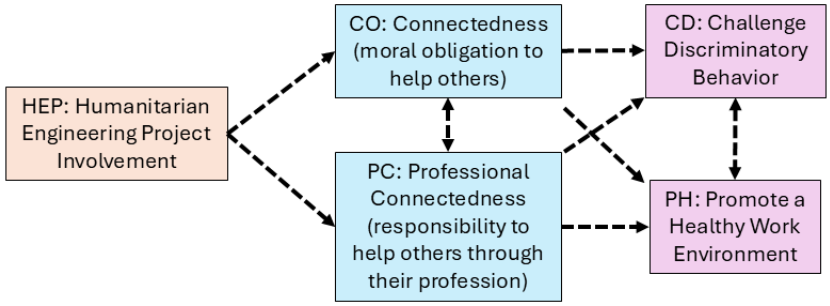

Figure 1: Significant correlations between the five factors are shown with bolding and dotted arrows

Given these potentially significant relationships, path models were built and tested using Partial Least Squares Structural Equation Modeling (PLS-SEM) tool in SmartPLS [14]. The Bootstrapping tool was used to find the path coefficients and determine significance. Following an iterative process, three models were the most successful as shown in Figure 2.

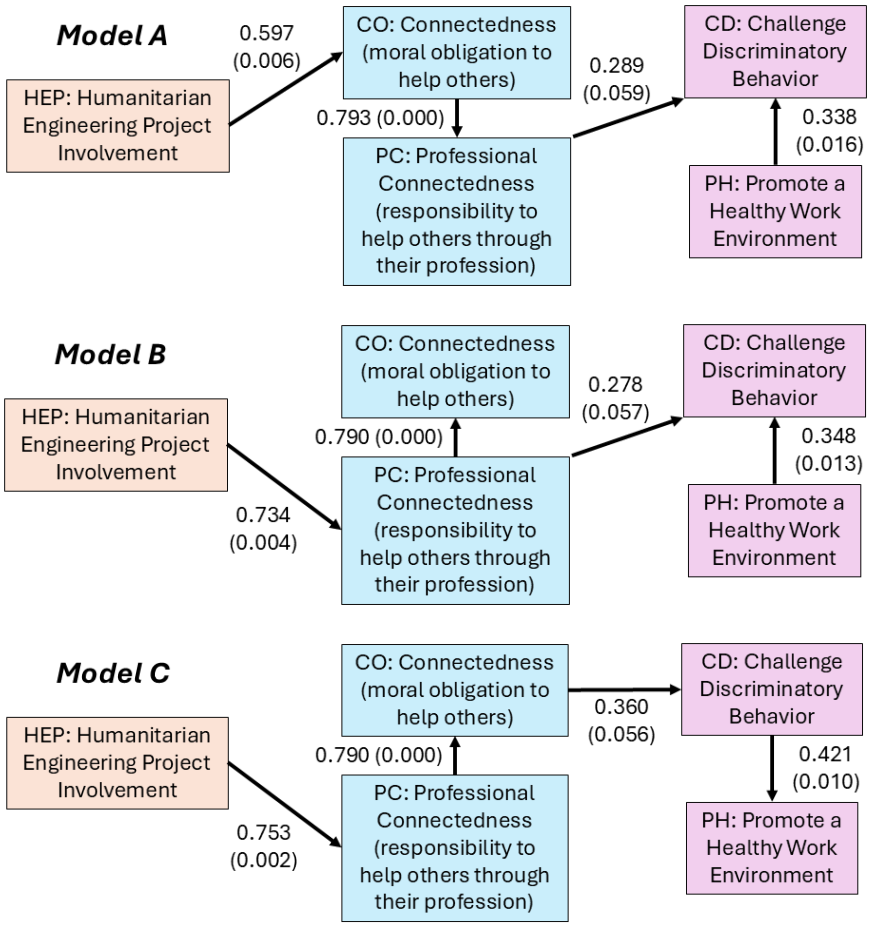

Figure 2: Three models A, B, and C representing the impact of HEP involvement on professional responsibility and inclusive behaviors - path coefficients with p-values

For all three models, the p-values are less than 0.05 except for the paths from *Connectedness (CO)* or *Professional Connectedness (PC)* to *Challenge Discriminatory Behavior (CD)* which hovered around 0.056-0.059 representing a nearly significant relationship. The path coefficients averaged 0.504, 0.538, and 0.581, from the first to third models, respectively. The third, Model C, also has the lowest average p-values (0.023), thus the authors propose that this is the strongest model tested supporting the relationships between HEP involvement, professional responsibility, and inclusive behaviors.

Interestingly, the model testing showed that HEP involvement predicted *Connectedness (CO)* or *Professional Connectedness (PC)*, but not both at the same time. Similarly, only one professional responsibility variable significantly predicted one of the inclusive behaviors, not both. From these models, it seems that generally HEP involvement has a significant impact on professional responsibility which then influences inclusive behaviors, but the path through these variables may vary. These results reflect the nuanced ways in which those who are involved in HEPs may process these experiences. For example, some may see the HEPs as providing insight on new perspectives from people other than themselves which then influences the way they perceive their role in the workplace (HEP > CO > PC). For others, HEPs may be an opportunity to practice a new type of connection through their profession which then influences their relationships to others (HEP > PC > CO).

From this analysis, the authors propose that involvement in HEPs influences a participant's feelings of obligation to help within and outside of their professional capacity. This obligation to help others may then influence the participant's likelihood to challenge discrimination in the workplace, yet this may also be dependent on their desire to promote a positive workplace culture. As such an obligation to help others is seen as a mediator between involvement in HEPs and inclusive behaviors. From these coefficients, indirect coefficients were calculated between involvement in HEPs and inclusive behaviors (specifically, *Challenge Discriminatory Behavior (CD))* through these mediators with values of 0.134, 0.206, and 0.142, respectively for the three models. Though this analysis cannot confirm causation between these parameters, it does provide a theory for potential further testing or investigation, especially with larger sample sizes. Luckily, these authors have already performed interviews and are able to uncover evidence pointing toward confirmation of this model.

Thematic analysis of 23 interviews with participants from the survey produced results that seem to confirm the path model proposed. Key themes uncovered from the qualitative portion of this study complement the path analysis [9]:

- Interviewees described how the ***quality time*** spent with teammates and the community through HEPs helped them to better understand others and to shape their social behaviors. Here, the HEPs provided an avenue to practice *Professional Connectedness* which could have led to a stronger desire to *Challenge Discriminatory Behaviors* as reflected in Models B and C.
- ***Relationships*** built through the HEPs, either within the team or with a client or community, seemed to serve as the primary motivator to practice inclusive behaviors from the interviews. Again, the HEPs provided an avenue to serve others, practice *Connectedness*, and learn from these experiences. Interviewees described how these relationships motivated them to *Challenge Discriminatory Behavior* as reflected in Model A and C.

- The ***purpose*** of HEPs, to create a positive impact, leads to a better team environment. Purpose could be described as *Connectedness (CO)* or *Professional Connectedness (PC)* whereas the better team environment directly relates to *Promote a Healthy Work Environment (PH).* Interestingly, the quantitative analysis showed no significant relationships between *CO-PH* nor *PC-PH* but Model C showed an indirect relationship between these with the mediator of *Challenge Discriminatory Behavior*. Though this may be considered a disagreement between the quantitative and qualitative portions of the study, it's possible the survey simply doesn't provide the depth of understanding that can be probed in an interview.
- Interview participants were asked how they might overcome the hurdle of hesitation that is common when encountering discrimination in the workplace. Ten of 21 participants directly connected their experiences from a HEP as motivation to challenge the discrimination (the first two interviewees were not asked this question). Though this relationship between HEP involvement and *Challenge Discriminatory Behavior (CD)* is shown with mediator variables in the path models, the interviews seemed to confirm that HEP is an impactful motivator for CD.

Conclusions:

From the path analysis, relationships certainly exist between involvement in HEPs, feelings of professional responsibility, and practicing inclusive behaviors. Accompanying qualitative results from interviews further support these causal relationships proposed by the path modeling. There are limitations to this study. The method of recruitment may have included some bias as most participants were recruited through connection with faith-based organizations. The survey included the question: "How important is religion in your life?" (Very important = 5, Somewhat important = 4, Not too important = 3, Not at all important = 2, Does not apply/prefer not to say = 1) with an average of 3.53 across 98 responses. It's possible that faith could be another factor influencing involvement in HEPs or a desire to help others but this was not included in the path analysis as faith was not of high importance among the respondents.

Of course, it's possible that there are other factors or variables not accounted for in these path modeling. Future work in this research area may include considering other factors such as faith and identity as to how their relationship with HEPs, professional responsibility, and inclusive behaviors. Though the sample size of 98 is more than ten times the number of free parameters, more responses could provide further insights or support for the proposed model. Additionally, perspectives from HEP programs outside of Lipscomb and the Peugeot Center would give alternative insights to the impact of involvement from a broader sense. While other factors or populations may provide new directions for research, the path analysis presented here indicates potential linkages between involvement in HEPs and its positive influence on participants' workplace environments. Based on these results and the accompanying qualitative analysis [9], the authors encourage engineering educators to consider utilizing HEPs (see reference [11]) as a potential avenue for creating a healthier and more inclusive engineering culture.

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