BOARD # 347: Creating Inclusive Engineers through Humanitarian Engineering Projects: A Preliminary Model and Framework for Integration (NSF RIEF)

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Ruth Fessehaye recently graduated from Lipscomb University with a Bachelor of Science in Mechanical Engineering and a minor in Applied Mathematics. She is set to begin her role in Saint-Gobain's Essentials of Manufacturing (EOM) Program, where she will focus on the biomedical engineering sector. Ruth is currently conducting research with Dr. Dodson, exploring how participation in humanitarian engineering projects influences individuals' perspectives on inclusion, equity, and diversity.

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Abstract:

This interactive poster will encourage audience members to review and provide feedback for a preliminary model and framework for integrating humanitarian efforts into engineering education for the purpose of creating inclusive engineers. The model and framework are the culminating work of an NSF RIEF-funded project focused on understanding the impacts of humanitarian engineering projects on student professional formation and views of diversity, equity, and inclusion. The project has included both quantitative methods through a survey and qualitative methods through interviews for a robust mixed method study to uncover these connections and impacts. From the surveys, the researchers found a lack of self-selection bias toward professional responsibility by those involved in humanitarian engineering projects. Additionally, the surveys found some differences in enacting inclusive behaviors across demographics like age and representation within the field. The interviews also produced interesting results, specifically two students whose experiences with inclusive behaviors were unexpected based on their identities - the student from an underrepresented background (veteran, mixed race) overcame bias toward teammates whereas the traditional white male student experienced inclusion. In addition to these narratives, the research team performed coding and thematic analysis of 23 interviews to better understand the connections between involvement in humanitarian engineering and enacting inclusive behaviors. From the results, a preliminary model and framework for creating inclusive engineers through humanitarian engineering was developed. The preliminary model is presented as a Venn diagram with three parts: technical abilities (traditionally taught in engineering), professional skills (only recently taught in engineering), and social and behavioral qualities (rarely taught in engineering). The research team proposes that while typical engineering projects tend to provide formation in technical abilities and professional skills, an emphasis on humanitarianism (at the center of the Venn diagram) can support development of crucial social and behavioral qualities like respect, humility, and empathy. Developing these qualities, though unexpected in most engineering programs and uncomfortable for many faculty, could be a key to creating more inclusive engineers. The model and framework will be the primary focus of the poster to encourage collaboration and interaction with the audience.

Keywords: humanitarian engineering, mixed methods, professional responsibility, diversity equity and inclusion

Introduction:

Traditional engineering education has focused largely on teaching technical knowledge and skills with a heavy emphasis on theory, problem-solving, and math/science concepts. Of course, these are foundational for competency as an engineer, but as described in a report published by the National Academies of Engineering, new engineering graduates lacked the skills to succeed professionally [1]. Though these new graduates were technically capable, they struggled with communication, teamwork, and other nontechnical expectations of the career field that grew through the 1980s. In response to these challenges, the Accreditation Board for Engineering and Technology (ABET) with support from various stakeholders developed new accreditation criteria that incorporated professional skills into engineering education which was adopted in 1997 through Engineering Criteria 2000 (EC 2000) [2]. A 2006 report on the impacts of EC2000 showed significant improvements in core professional competencies like teamwork, communication, lifelong learning, and engineering design [3]. Many of these skills are now commonplace in engineering programs and are even directly incorporated through the curriculum or indirectly through support extracurricular activities. Engineering service-learning and humanitarian engineering projects (HEPs) have been well-studied with respect to these two competencies and have shown positive impacts on technical and professional skills [4, 5]. More recently, a new set of qualities has been studied in engineering education that includes capabilities like empathy, identity, and perseverance [6-8]. Though many have lumped these qualities into professional skills, this project proposes that these should be seen as a separate yet still vitally important part of educating engineers. Here, the authors propose to define these as social/behavioral qualities and suggest that these qualities complement the technical capabilities and professional skills. Figure 1 is a visual representation of the intersection of these three competencies providing an introduction to the model presented in this poster with further explanation following.

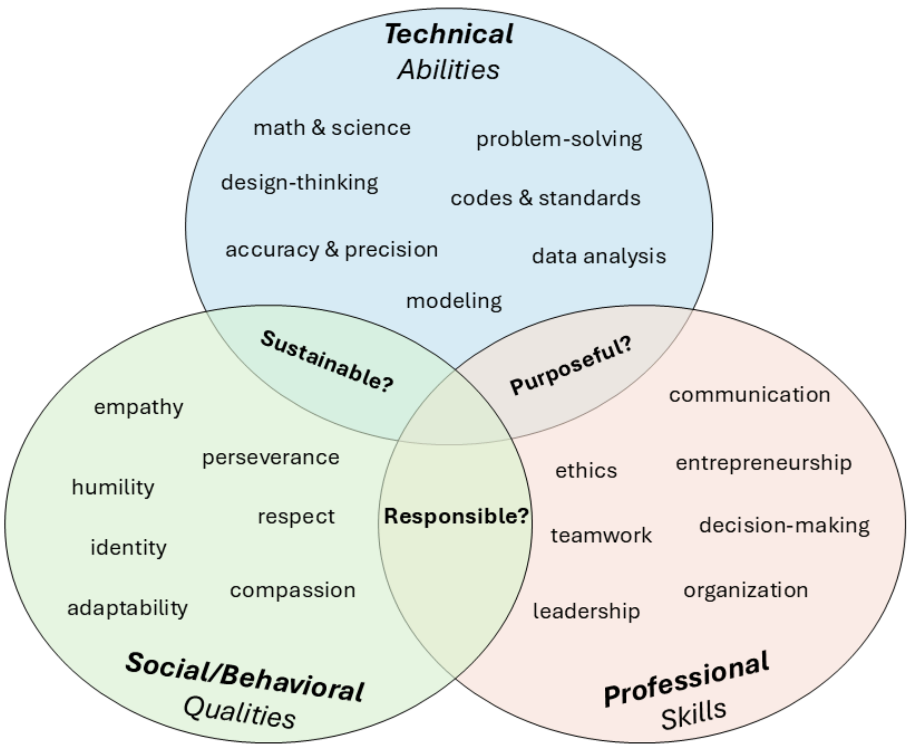

Figure 1: The intersection of three main competencies proposed for engineering education

Technical + Professional - Social/Behavioral: While it's quite possible that many engineering roles may function in this area, the authors propose that engineers may feel a ***lack of purpose*** that drives their commitment or passion for their work. This could also be viewed as the current state of engineering education that emphasizes technical capabilities, incorporates some professional skills, but seemingly avoids any mention of social and behavioral qualities.

Social/Behavioral + Professional - Technical: Completing engineering projects without the appropriate technical capabilities is widely regarded as ***irresponsible***. Licensure and codes of ethics tends to prevent these occurrences though it is still important to remind students of the potential downfalls stemming from a lack of technical expertise.

Technical + Social/Behavioral - Professional: Having the technical abilities and the social/behavioral qualities to work on a project may lead to satisfactory completion, but may ***lack the sustainability*** of a well-managed project. Disorganization, a dysfunctional team, and poor communication cause major frustrations for any project and could impede not only the success of a project but also the future of the organization.

Technical + Professional + Social/Behavioral: At the center of the model sits a 'sweet spot' where all three sets of competencies are achieved creating what could be considered a ***high quality engineer***. This project proposes that these three competencies can be taught or encouraged through ***humanitarian engineering projects*** (HEPs).

<u>Methods and Results:</u>

This NSF RIEF-funded study has incorporated both quantitative methods through a survey and qualitative methods through interviews. The study was deemed exempt from full review by the Institutional Review Board at Lipscomb University. Three participant groups were included in the study: current engineering students at Lipscomb University, alumni of Lipscomb's engineering programs, and engineering professionals who are not affiliated with Lipscomb. Many of the students and alumni of Lipscomb have participated in HEPs through the Peugeot Center, which has been well-documented in [9]. The survey was designed based on two existing instruments to study beliefs around personal and professional responsibility (Engineering Professional Responsibility Assessment [10]) and views of equity and inclusion in the field (Valuing Diversity and Enacting Inclusion in Engineering [11]) with Likert-scaled items. Two open-ended questions were also included in the survey: "Explain your primary reason for volunteering or serving" and "Briefly describe an event that has influenced your views of diversity, equity, and inclusion." Coding and thematic analysis from these open-ended questions produced a codebook and many of the initial terms included in the model in Figure 1 [12]. Interestingly, the survey did not produce meaningful results related to the model, but did remove suspicion around self-selection bias - those who elected to participate in HEPs did not have higher levels of professional responsibility nor stronger views around inclusivity [13]. It's possible that these interconnections between HEPs, professional responsibility, and views of inclusivity are challenging to uncover through quantitative methods and are better studied through a qualitative research method like interviews. The semi-structured interview was designed to elicit these more complex connections between participation in HEPs and views of professional responsibility and inclusive behaviors. Interviews with two students unveiled interesting results, especially around identity and inclusive behaviors, as well as some initial strategies for how HEPs impact a student's views around responsibility and inclusivity [14].

Though not clearly represented in the model in Figure 1, the authors of this project propose that a high quality engineer is one that exhibits technical expertise, professionalism, and positive behaviors. These positive behaviors improve not only the tasks and work of the engineer (external), but also their workplace environment (internal). From 23 interviews across all three participant groups, three common themes emerged that connect participation in HEPs to positive workplace behaviors [15]. First, when comparing HEPs and their current engineering workplace, interview participants noted that the purpose behind the HEPs was a strong motivator that brought the team closer together. Second, participation in HEPs requires significant physical proximity with teammates as well as discomfort, both physically and mentally, that creates stronger bonds. This motivation for the team and bonding that occurs provides exposure to diversity and reinforces inclusive behaviors in the workplace. Lastly, relationships are critical for challenging discrimination, but in two different ways. A strong relationship with a recipient of discrimination can motivate someone to challenge discrimination, but also a strong relationship with the offender allows for a lower barrier to making a correction in the behavior. An important aspect of HEPs is building relationships which, though uncomfortable at times, is strengthened by purpose and physical proximity or quality time.

From all of these parts of the study, an initial framework (Figure 2) has also been developed to guide engineering educators on how to design HEPs such that they create inclusive engineers. As shown, the framework presents an overview of how HEPs engage students in learning and practicing technical abilities, professional skills, and social (behavioral) qualities. The project activities are shown as external to the process with interactions among the client or community throughout, resulting in internal reflection by the participating student. The 5-phase project cycle is based on the Introduction to Engineering for Global Development design process from Engineering for Change which is strengthened by its emphasis on collaboration with the served community or client [16]. The model and framework will be presented in the poster with the intention to receive thorough and thoughtful feedback from engineering educators.

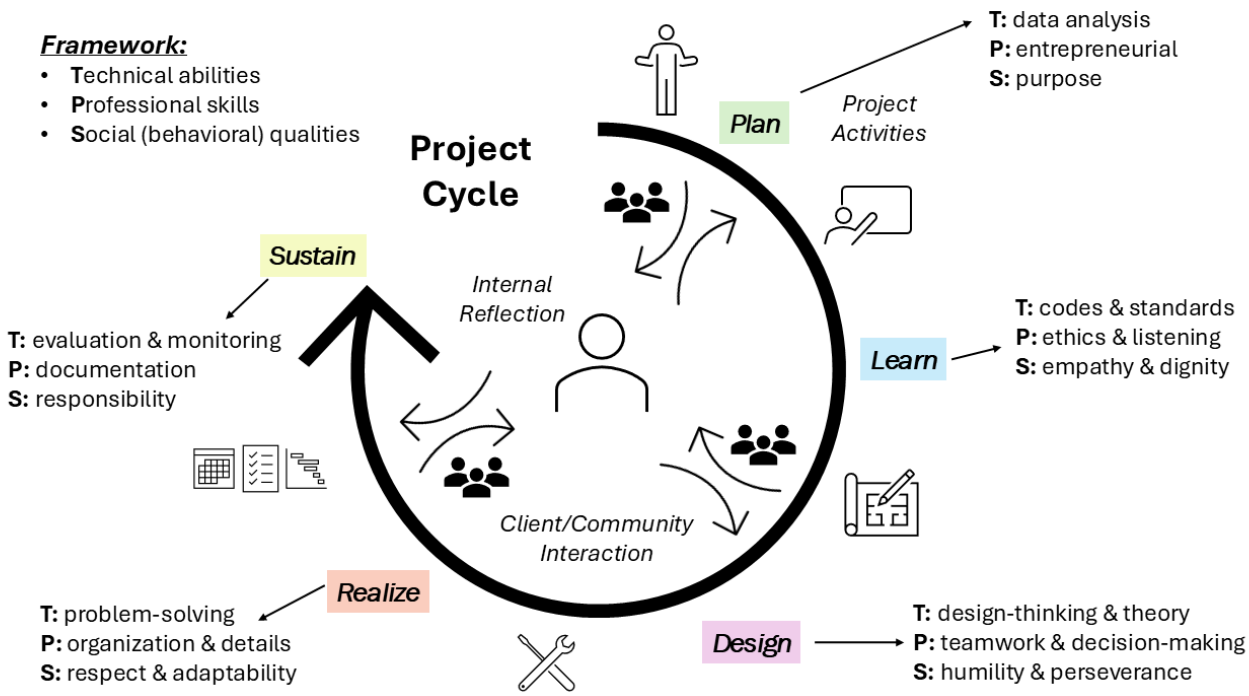

Figure 2: Initial framework for creating inclusive engineers through a HEP cycle

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