The "Soft" Argument for Engineering Professional Identity Courses: A Case Study

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Introduction

The increasing demands for a 21st century postsecondary education-- that incorporates the liberal arts, humanities, and social sciences--in contrast to the stasis of engineering curriculum, has catalyzed an engineering education "identity crisis" [1]-[9]. Without an understanding of the engineering norms, practices, and worldviews that engineering students and instructors carry from their courses, there is an increased risk that underrepresentation in engineering will continue to persist.

This work aims to expand a previously developed study on *engineering professional identity* by exploring two unique engineering courses (serving as case studies) at a college of engineering at a western institution in the U.S. One course focused on helping engineering students develop technical communication skills while the other course aimed to help underrepresented women in engineering to understand about and plan for careers in engineering. Both cases are uniquely positioned to help engineering education researchers elucidate how professionally-focused and career-planning engineering courses could guide students' perceptions about engineering.

Framework

In 2017, Villanueva and Nadelson developed a working definition of *engineering professional identity* in response to the term being conveyed inconsistently in the literature [10]. In turn, the authors sought to create a working definition of engineering professional identity that considers how "seasoned professionals might self-describe who they are in relationship to their profession" [10, p. 640]. Furthermore, the working definition was developed to consider sources of information and interactions that are derived from individual, social, and systemic experiences and that these are not fixated with time and experience.

Engineering professional identity is more holistic and requires an integration between how an individual develops an identity (formational identity) and how they perceive their identity within a profession (professional perceptions; Figure 1; [11]).

Figure 1. Proposed relationship between formational identity and professional perceptions about engineering

Research Questions and Design

In engineering courses where professional skill development and career exploration/planning are central, how do engineering students' perceptions of the field vary?

RQ 1: In what ways are the course instructors' perspectives similar or different to students' perceptions of engineering?
RQ 2: In what ways (if any) does gender and level of engineering education influence students' perceptions of engineering?

Participants
Twenty-four undergraduate engineering students (primarily juniors and seniors; 98% male) in a Technical Communication course and 20 women undergraduate students (primarily freshmen and sophomore; 100% female) in a Women in Engineering course in a rural western U.S. university participated. Disciplines included Mechanical Engineering, Computer Science, Civil and Environmental Engineering, and Electrical and Computer Engineering. All procedures were compliant with Institutional Review Board policies.

Data Collection
Students were provided with a semi-structured survey developed by Villanueva and Nadelson [10]. The survey questions were self-reflective in nature and designed to gather data representative of the students' perspectives of themselves as engineers and of the field. The same questions were provided to the instructors to complete in written form via email.

Data Analysis
Axial and thematic coding of the responses occurred for the survey responses to these questions. Interrater reliability was derived among three individuals who had over a 90% agreement in the codes. Instructor responses were also coded in a similar fashion and were member-checked with the instructors themselves.

Results

- Regardless of course, students and instructors stated that one of the primary roles of engineers entails that of a *Designer/Tinkerer* (Table 1 below).
- For both courses, the individual domain (involving an individuals' identification to a profession via knowledge and internalized factors) was greatest; Table 2 to the right).
- For the Women in Engineering course, students changed the most between individual and social domains with no changes in the systemic sources.

Table 1. Representative quotes of engineering students' and instructors' responses about their perceptions of engineering

Foci		Mediator	Designer/Tinkerer	Social/Servant
Technical Communication (Junior-Level)	Professional competency development around technical communication	**Students (18%):** "An engineer is someone who can apply knowledge of physics, chemistry, biology, math, how the nature/world works." (ID 03) **Instructors (0%):** N/A	**Students (47%):** "An engineer is someone who takes the time to think through a problem and find a solution. They have a technical knowledge of engineering principles." (ID 04) **Instructors (50%):** "Engineer is both a noun and verb. An engineer is a problem solver. An engineer is someone who can look at all the "parts" and create a "whole" that is better than the individual parts." (ID 01)	**Students (35%):** "a person who seeks to improve the quality of their own life and the lives of others by creating innovative things or ideas with the resources available to them." (ID 07) **Instructors (50%):** "An engineer is an individual who uses his/her creativity, problem-solving skills, ingenuity, and analytical skills to improve quality of life. Engineers influence all aspects of daily life: including the water we drink, the food we eat, the cars we drive, the medicines we take, the galaxies we explore"(ID 02)
Women in Engineering (Freshmen-Level)	Career Exploration on Engineering Careers	**Students (46%):** "Applied science to help others and solve problems by developing innovative solutions"(ID 13) **Instructor (0%):** N/A	**Students (13%):** "Learning to solve problems in new ways to make situations better, more efficient and safer"(ID 06) **Instructor (0%):** N/A	**Students (42%):** "Engineering is solving a problem to improve a part of our lives" **Instructor (100%):** "An engineer is an individual with specific knowledge, training and skills, who uses the knowledge, training and skills to solve individual and societal problems, enhance quality of life, advance technologies, and explore our world and beyond"(ID 03)

Table 2. Representative examples of students' perceptions during the middle of the semester (Technical Communication Course) or middle to end of the semester (Women in Engineering course)

Foci		Sources for Perceptions about Engineering
Technical Communication (Junior-Level)	Professional competency development around technical communication	**Students:** **Individual (54%):** -"I would not consider myself an engineer to a hundred percent before I started working as one after my studies. But I believe I have a mindset of an engineer. I think of solutions not problems." (ID 26, File 03) **Social (13%):** -"Being able to unify everyone's ideas to conform the best solution." (ID 13, File 05) -"A successful professional engineer communicates clearly and honestly with clients, co-workers, and others." (ID 54, File 05) **Systemic (33%):** -"Working on [identifier removed] team has helped me gain these skills: I have learned to document my work clearly for other teammates to view; I have learned the importance of meetings and keeping to an agenda, and many other things pertinent to the nature of engineering, because we have placed ourselves in such an environment; not a classroom." (ID 50, File Name 06) -"A professional should be proficient with engineering practices. A professional must be a continual learner." (ID 54, File 05) **Instructors:** **Individual (62%):** -"Math is the skill that springs to mind first, but there are more skills that define a professional engineer. A "professional" has a level of expertise, responsibility, and accountability that he or she lives up to." (ID 01, File 03) **Social (38%):** -"Engineers do not work in vacuum. They must be able to work with other people. People skills such as conversation, conflict management, trust, and credibility are essential." (ID 01, File 03) -"The essential skills of an engineer go beyond technical skills. To be an engineer, students must also develop communication (written, oral, interpersonal), teamwork, initiative, problem-solving, leadership, and analytical skills." (ID 02, File 02) **Systemic (0%):** N/A
Women in Engineering (Freshmen-Level)	Career Exploration on Engineering Careers	**Students:** **Individual (80% to 45%):** -"I would consider myself as an engineer; I feel that I am capable of the mindset and thought processes needed."(ID 04, File 01) -"I do not consider myself an engineer because I have no skills, or knowledge base to solve important problems. If I am an engineer then anyone can be one, and then there is no point in working hard for four years." (ID 12, File 01) **Social (20% to 55%):** -"Everyone has contributions to add, and engineers need to be willing to accept, and carefully consider suggestions and proposals." (ID 14, File 02) **Systemic (0% to 0%):** N/A **Instructor:** **Individual (52%):** -"Many engineering students think the only things they need to be a good engineer are technical skills." (ID 03, File 01) **Social (36%):** -"Having been in the engineering workforce, I know firsthand the necessity of communication, teamwork, leadership, and many other transferable skills…I repeatedly emphasize the critical need of involvement beyond the classroom, in research, clubs, student projects, etc." (ID 03, File 01) -"I advise and mentor engineering students in various clubs and organizations so they can gain necessary professional skills." (ID 03, File 01) **Systemic (12%):** -"Transferable skills are gained and strengthened in non-classroom environments." (ID 03, File 02) -"…Life-long learning as tools and technologies improve." (ID 03, File 03)

Discussion/Next Steps

Students' and instructors' description of engineers as *Designers/Tinkerers* suggests that professional engineering courses may influence students' perspectives of engineering but may not be sufficient to help them shift to a *Social/Servant* perspective. This may require a more connected community and societal experience (e.g., service-learning) in their engineering education [12], [13]. In comparing both courses, there appears to be a gender-specific role in the formation of students' identification with the profession.

Interestingly, the lack of change in the systemic domain for the Women in Engineering course suggests that there is a lack of familiarity about the systemic factors (e.g., accreditation) in engineering among female students [14], which may limit the full development and solidification of an engineering professional identity [10], [15]. Future research will use a more granular approach to understand how the framing and structure of a course may influence students' perspectives about engineering. Also, experiences of faculty will be explored further.

Implications for Practice

The findings from this preliminary study may help engineering educators uncover how courses (and their instructors) shape perspectives of engineering and of their roles in the field. Findings suggest that there is a gendered-role in students' perspectives of engineering as it relates to the domains that students use in describing the work and skills of engineers. While professional engineering courses may help students identify a "more modern" view of engineering, it may not be sufficient to fully shift students' perspectives to a Social/Servant definition of engineering professional identity, which is closer to what a 21st century society needs. Possibly complementing instruction with service learning experience may help students develop a more holistic view of engineering.

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