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

Introduction

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 careerplanning 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]).

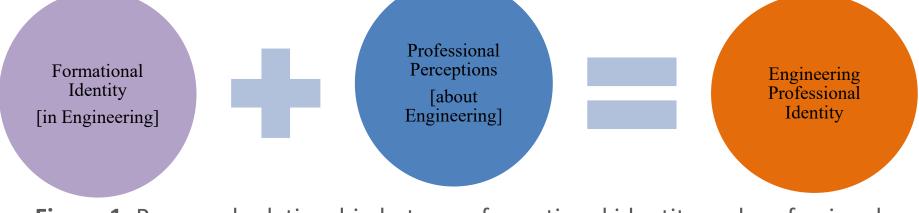


Figure 1. Proposed relationship between formational identity and professional perceptions about engineering

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).



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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

Foci

ndividual (54%):

Social (13%):

Systemic (33%):

others." (ID 54, File 05)

learner." (ID 54, File 05)

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

responses about their perceptions of engineering					Ŭ	ď	Individual (62%):
	Foci	Mediator	Designer/Tinkerer	Social/Servant	ical	JcV	-"Math is the skill that spring engineer. A "professional" ha up to." (ID 01, File 03) Social (38%): -"Engineers do not work in va conversation, conflict manag -"The essential skills of an er develop communication (wri leadership, and analytical ski Systemic (0%): N/A
Technical Communication (Junior-Level)	evelopment around technical unication	Students (18%): "An engineer is someone who can apply knowledge of physics, chemistry, biology, math, how the nature/world works." (ID 03)	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)	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)	(Freshmen-Level) Technical C	Professional competency de	
	Professional competency developme communication	Instructors (0%): N/A	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)	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)		Engineering Careers	Individual (80% to 45%): -"I would consider mysel processes needed."(ID 04 -"I do not consider mysel important problems. If I a working hard for four yea Social (20% to 55%): -"Everyone has contributions suggestions and proposals." Systemic (0% to 0%): N/A
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) 	Women in Engineering(Career Exploration on Eng	Individual (52%): -"Many engineering student (ID 03, File 01) Social (36%): -"Having been in the engineering teamwork, leadership, and minvolvement beyond the class -"I advise and mentor enginering necessary professional skills. Systemic (12%): -"Transferable skills are gainering -"Life-long learning as tools



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) Sources for Perceptions about Engineering

-"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

"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

"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

Instructors:

that springs to mind first, but there are more skills that define a professional ssional" has a level of expertise, responsibility, and accountability that he or she lives

work in vacuum. They must be able to work with other people. People skills such as flict management, trust, and credibility are essential." (ID 01, File 03) Ils of an engineer go beyond technical skills. To be an engineer, students must also cation (written, oral, interpersonal), teamwork, initiative, problem-solving, alytical skills." (ID 02, File 02)

Students

ider myself as an engineer; I feel that I am capable of the mindset and thought

ded."(ID 04, File 01) sider myself an engineer because I have no skills, or knowledge base to solve blems. If I am an engineer then anyone can be one, and then there is no point in for four years." (ID 12, File 01)

ntributions to add, and engineers need to be willing to accept, and carefully consider roposals." (ID 14, File 02)

ng students think the only things they need to be a good engineer are technical skills."

he engineering workforce, I know firsthand the necessity of communication, ship, and many other transferable skills...I repeatedly emphasize the critical need of nd the classroom, in research, clubs, student projects, etc." (ID 03, File 01) ntor engineering students in various clubs and organizations so they can gain ional skills." (ID 03, File 01)

Is are gained and strengthened in non-classroom environments." (ID 03, File 02) ing as tools and technologies improve." (ID 03, File 03)

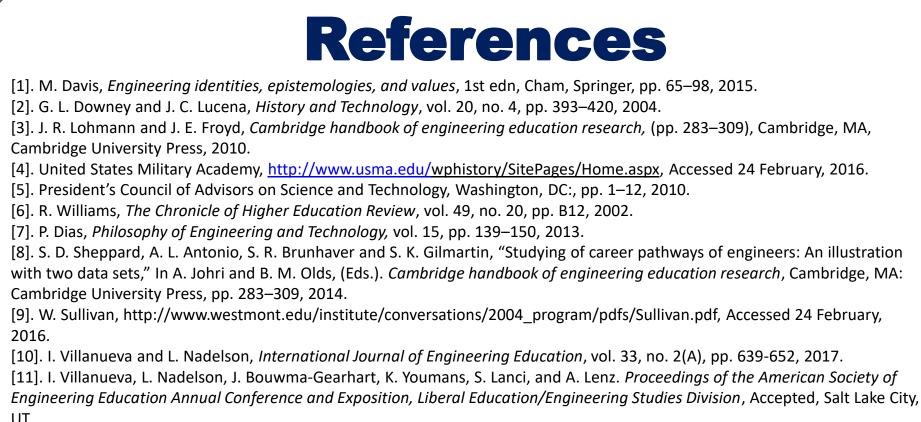
Discussion/Next Steps

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.



2016.

UT. [12]. L. Whitman, K. Reynolds, and Z. Toro-Ramos, Annual Conference of American Society of Engineering Education, 2011. [13]. W. Oakes, *Higher Education*, Paper 165, 2004. [14]. J.W. Pellegrino, and M.L. Hilton, National Research Council, National Academies Press, Washington, D.C., 2012. [15]. I.Villanueva, "IEEE Frontiers in Education Conference, 2015.



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