Engineering Personas Through the Lens of First-Year Engineering Students

Miranda Brown, Virginia Polytechnic Institute and State University

Miranda Brown is a first-year PhD student in the Department of Engineering Education at Virginia Tech. Her research interests include women's experiences in engineering, how students perceive grades and feedback, and student motivation. Miranda got her MS and BS in Industrial and Systems Engineering from Virginia Tech.

Cassie Wallwey, Virginia Polytechnic Institute and State University

Dr. Cassie Wallwey is a Collegiate Assistant Professor in the Department of Engineering Education at Virginia Tech. Her research interests center on student-centered and inclusive learning practices and principles including student engagement in learning, feedback and assessment, self-regulation of learning, and student motivation. Cassie got her PhD in Engineering Education from Ohio State University and her MS and BS in Biomedical Engineering from Wright State University.

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Abstract

Women have historically been underrepresented in STEM. Despite continued efforts to broaden the participation of engineers and create more inclusive environments in engineering places of teaching, learning, and professional practice, women and other minorities continue to remain underrepresented in the field of engineering. Increasing the overall participation within the field of engineering is beneficial to fostering a more productive and creative engineering environment because a diverse team brings a broader range of perspectives, thus creating more innovative design solutions. Likewise, the team of engineers best served to design solutions to problems in society is one that closely represents the demographics of society to ensure designs are accessible to everyone.

This study aims to analyze the societal perceptions of who an engineer is through the lens of first-year engineering students at a large, public university. Previous research has found that students often share the preconceived stereotypical associations of masculinity with the field of engineering. For this study, data came from the project submissions of about forty different first-year engineering student teams. For this project, students created personas of engineers who they believed to have contributed to the creation of a product or process they selected to deconstruct and study. The data were analyzed by quantifying the demographics of the personas created, as well as comparing the demographics of the teams to the demographics of the personas those teams created. Results indicate that the populations underrepresented in engineering in society are also underrepresented by the personas created by students. This study further stresses the importance of increasing efforts to further understand when and how societal perceptions about what engineers look like are formed, as even with the broadening participation in the field, aspiring engineers continue to visualize engineers in ways that align with stereotypes and majority identities within the field.

Introduction & Background

The field of engineering within the United States has historically been dominated by white males, and even with efforts to broaden participation within the field of engineering, women remain in the minority [1]. While the recruitment of populations of folks who have been traditionally underrepresented in engineering is a current focus in efforts to broaden participation within undergraduate engineering programs, the next issue is retaining the underrepresented students that enter these programs [1], [2]. Harmful stereotypes against women contribute to the underrepresentation of women in the field of engineering [3]. Stereotypes that frame women as bad at math or as lacking technical skills are detrimental to the recruitment and retention of women within the field [1], [4], [5]. Women are often stereotyped as excelling in jobs that involve utilizing social skills; however, engineering is seen as a technical career path for those that are good with computers and tinkering [2], [6]. This causes many women and others with

aspects of their identities being underrepresented in STEM disciplines to lose interest in the field of engineering due to the masculine perceptions of the field.

The underrepresentation of women in the field of engineering can cause negative impacts on the self-efficacy of women and contribute to the high rate of women switching to different careers outside of engineering, which discourages other women from pursuing engineering in the first place [2]. This can quickly create a negative cycle as women begin to doubt their ability to persevere in an engineering program due to the lack of other women existing in their engineering support system and their own self-doubt in their abilities based on these gendered societal stereotypes [7]. Broadening participation within engineering is important to the formation of high functioning and innovative teams of engineers [8]. A team filled with engineers from different backgrounds and lived experiences will be better equipped to address global issues [9], due in large part to the fact that diverse teams are more efficient due to the sharing of differing perspectives [10], [11].

The societal perceptions and gendered stereotypes within engineering motivated this research exploration. To recruit more engineering students, we posit that it is helpful to understand how first-year engineering students view and perceive engineering professionals. Societal perceptions and biases of identities that "can or cannot" be engineers or which identities most often are or are not engineers have likely influenced the beliefs and perceptions of incoming engineering students; however, there are few studies specifically exploring how these societal beliefs or perceptions may manifest for early engineering students beyond measures of their own identities and self-efficacy. Our research in this paper will explore an alternative means to identify if first-year engineering students tend to associate certain gender or racial identities with engineers over others. This will be done by analyzing submissions of a project in a first-year engineering course in which students created fictional engineering professionals.

Theoretical Underpinnings

The theory of technical dualism - first proposed by Wendy Faulkner in 2000 - is what sparked the curiosity that ultimately led to the exploration of data in this paper. This theory is a technology-focused version of the traditional gendered dualism theories which stereotype various actions and qualities with masculine and feminine traits [6]. The theory of technical dualism proposes that gender is divided and associates masculine instrumentalism with technology-focused traits and feminine expressiveness with people-focused traits. Within the theory, these distinctions are mutually exclusive, and individuals are seen to either have a greater enthusiasm for technology-focused traits or people-focused traits based on their gender [6], [12]. This theory defines the core of the engineering identity as "tinkering" with things and working almost exclusively with technology – both traits being considered masculine.

The perceptions and stereotypes of technical dualism are the foundation of the social perceptions of engineers. The stereotypical definition of an engineer has historically been a cisgendered white male who enjoys tinkering and working with technology [2], [6]. This is a detrimental stereotype when attempting to broad participation the field of engineering to meaningfully include women and other minorities, as people who hold these identities may be discouraged from pursuing engineering due to the concerns that they will not fit in with the stereotypically masculine identity of an engineer.

Purpose

This exploration utilizes technical dualism to explore the identities that first-year engineering students assign to fictional professional personas (both in engineering professions and non-engineering professions) they create as part of a group project in a first year engineering course and how the identities of the fictional engineering personas do or do not reflect technical dualism and the majority identities in engineering with regards to gender and race / ethnicity. Previous research has found that engineering students often share the preconceived stereotypical associations of masculinity with the field of engineering and more feminine social traits associated with jobs outside of STEM fields [2], [6]. This study explores the fictional personas of working professionals created by first-year engineering students as an alternative means of exploring how technical dualism may be pervasive in engineering students' beliefs and perceptions about what gender and racial identities are associated with engineering professionals or professionals in other fields.

This exploration detailed in this paper will answer the following research questions

> RQ 1: What genders and races/ethnicities do first-year engineering students appear to be assigned to fictional personas of working professionals in engineering fields and non-engineering fields?
>
> RQ 2: How do the demographics of the fictional engineering professional personas compare to the demographics of students enrolled in the class, the national demographics of engineering students, and national demographics of who holds engineering jobs?
>
> RQ 3: To what extent does the prevalence of non-majority (non-male and non-white) identities on a team of first-year engineering students relate to the prevalence of non-majority (non-male and non-white) identities appearing in the fictional engineering personas students created?

Positionality Statement

Both authors of this paper identify as white women in engineering who have both encountered challenges associated with being females in a male-dominated field, including questioning of their own abilities and "fit" in engineering throughout their educational programs and careers. The authors were motivated to pursue the research exploration detailed in this paper after learning about the theory of technical dualism and sharing anecdotal evidence of their experiences as both students and faculty and how the beliefs associated with that theory appear to persist in present-day engineering classrooms. To mitigate biases that the authors' identities may introduce into the research, researchers with gender and racial identities different from those of the authors were invited to consult throughout data analysis and interpretation of the results.

Research Methods

Study Context & Participants

This exploration was conducted by collecting data from assignments submitted for assessment of learning outcomes in a first-year engineering course. The data for this study came

from six sections of ENGE 1215 between Fall 2022 – Winter 2025, totaling approximately 350 students. Because the data collected were deliverables for the course and that the data de-identification prior to our further analysis for this exploration, no IRB or consent wavers were required as determined by the Human Research Protection Program Institutional Review Board at Virginia Tech.

In this course, students were grouped into teams using CATME software. This software groups students into teams based on students' self-reported information such as gender, race, weekly schedules, comfort, and experience with various engineering skills and tools, etc. Weights of importance were assigned to each of these factors when forming teams, with the highest weight of importance being given to not isolating any racial or gender identities that are underrepresented in the field of engineering on a team. After being assigned to groups, students were assigned a project in which the group would select a product or process of their choosing to 'deconstruct' or 'reverse engineer.' As the student groups reverse engineered a product / process, they we are instructed to consider the engineers from differing disciplines and other working professionals who likely formed a team of professionals who would collaborate to contribute to the creation or maintenance of that product/process. One deliverable of this project was the creation of faux LinkedIn profiles illustrating and giving "life" to fictional personas of the team of identified engineers and other professionals necessary to create or maintain the product/process. Each faux LinkedIn profile for each fictional professional persona (engineering or otherwise) was required to have a profile picture, list their workplace, educational background, engineering discipline/profession outside of engineering, and role within the larger team. Students were given a template to create faux LinkedIn profiles for both the engineering and non-engineering fictional professional personas. Canvas, the learning management system used for course facilitation, was utilized in the collection of team assignment submissions.

Data Collection, Processing, & Analysis

Two forms of data were collected from two different sources for the exploration described in this paper. The first set of data collected was the self-reported gender and race/ethnicity of the students enrolled in the course through the CATME surveys for the purpose of team formation. The second set of data collected was the groups' submissions for the professional faux LinkedIn profiles collected from Canvas.

To protect the identities of the students, the Primary Investigator removed the names of the students before analysis by study personnel. Only the gender and race/ethnicity of each student on each team was provided. Unlike the gender and race/ethnicity of the students enrolled, the gender and race/ethnicity of the fictional professional personas created by students were not self-reported. Data preparation for analysis and processing involved the research team conducted two rounds of data coding in which the gender and racial identities of the fictional personas were evaluated and scored as either seemingly belonging to the majority gender identity in engineering (man) [scored 0] or being diverse from the majority gender identity in engineering in the US (women, transgender, other) [scored 1]. These gender determinations were made through a combination of visual inspection, traditional assignment of masculine or feminine names, assigned pronouns or use of pronouns in the profile, or a known gender if students choose a public figure. A similar process was used for the race/ethnicity - evaluating each persona as either seemingly belonging to the majority racial/ethnic identity in engineering (white) [scored 0] or being diverse from the majority gender identity in engineering in the US (Asian, Black,

Hispanic, Native American, Middle Eastern, Other, etc.) [scored 1]. These racial/ethnicity determinations were made through a combination of visual inspection or a known race or ethnicity if students choose a public figure.

To conduct data analysis and answer our research questions, the number of students reporting gender identities different from the US engineering majority and racial identities different from the US engineering majority were tallied and compared to national averages. This same process was repeated with the coded and scored identities of the professional personas created by student teams. Additionally, variations from the majority gender and race/ethnicity identities within student teams were compared to variations from the majority gender and race/ethnicity identities within the teams of engineering personas they created to identify if there was any sort of relation between the identity variation from the majority within a team of students compared to identity variation from the majority of the identities they assigned to professional engineers.

Limitations

This exploration and its result are limited in a few ways given the context of the work and circumstances of both data collection and analysis. All but one of the 6 sections these assignment submissions were collected from were all taught by same white, female engineering faculty member. The identities the professor holds and her professional background in a traditional engineering discipline – all shared with students – may have influenced the race or gender they assigned to some fictional engineering personas. Another significant limitation of this exploration is the data processing in which genders and race/ethnicity of the fictional professional personas were evaluated and scored. While many steps were taken to reduce this threat (utilized multiple data coders with varying genders and races to complete this exercise and cross-reference responses until a consensus was reached across all researchers) students were not asked explicitly to report the gender or race/ethnicity identities they intended their fictional personas to hold, so these evaluations and scores were all ultimately subjectively decided upon.

Results

Table 1, provided below, shares the result as they relate to RQ 1: “What genders and races/ethnicities do first-year engineering students appear to be assigned to fictional personas of working professionals in engineering fields and non-engineering fields?”

Table 1: Gender and Race/ethnicity Diversity of Personas

	Gender (percent of gender identities other than solely “male”)	**Race** (percent of racial identities other than solely “white”)
Engineering Persona	19.93%	26.80%
Non-Engineer Persona	31.79%	24.50%

The engineering personas created by first-year students were scored to have gender identities different from the majority gender identity in US engineering contexts for 19.93% of the personas. In other words, 19.93% of the personas as represented by students and interpreted by our research team held a gender identity other than male.

Likewise, 26.80% of the fictional engineering personas seemed to hold a diverse race/ethnicity other than solely "white". This shows that students most often created fictional engineering persona identities that aligned with the majority gender and race/ethnicity identities of engineers in the US; however, there appeared to be some diversity represented in the personas created. 31.79% of the non-engineering professionals appeared to have non-male gender identities, which is 11% higher than the representation of the engineering personas. Race/ethnicity representation was consistent across engineering and non-engineering personas.

Table 2, provided below, shares the result as they relate to RQ 2: "How do the demographics of the fictional engineering professional personas compare to the demographics of students enrolled in the class, the national demographics of engineering students, and national demographics of who holds engineering jobs?"

Table 2: Gender and Race/Ethnicity of Personas, Students, and National Averages [12], [13]

	Gender (percent of gender identities other than solely "male")	**Race** (percent of racial identities other than solely "white")
Engineering Persona	19.93%	26.80%
Student Diversity	23.08%	55.56%
National Demographics of Undergrad Eng. Students	24.6%	46.6%
National Demographic of Engineering Professionals	~15%	~29%

The engineering personas created by first-year students were scored to have gender identities that were slightly lower than the diversity of the students in the course, as well as the national demographics of engineering students as defined by ASEE statistics [13]. These levels were, however, slightly higher than the national averages of engineering professionals.

The race/ethnicity representation of the fictional personas was found to be much lower than the representation within the student population and overall national averages. 26.80% of the fictional personas seemed to hold a diverse race/ethnicity, while 55.56% of the students within the course reported holding identities outside of the majority. Both gender and race/ethnicity representation were higher within the class and national undergraduate student averages than is seen within engineering professionals in the US.

Figures 1 and 2, provided below, shares results as they relate to RQ 3: "To what extent does the prevalence of non-majority (non-male and non-white) identities on a team of first-year engineering students relate to the prevalence of non-majority (non-male and non-white) identities appearing in the fictional engineering personas students created?"

Figure 1: Gender Diversity, Team vs Fictional Persona (%)

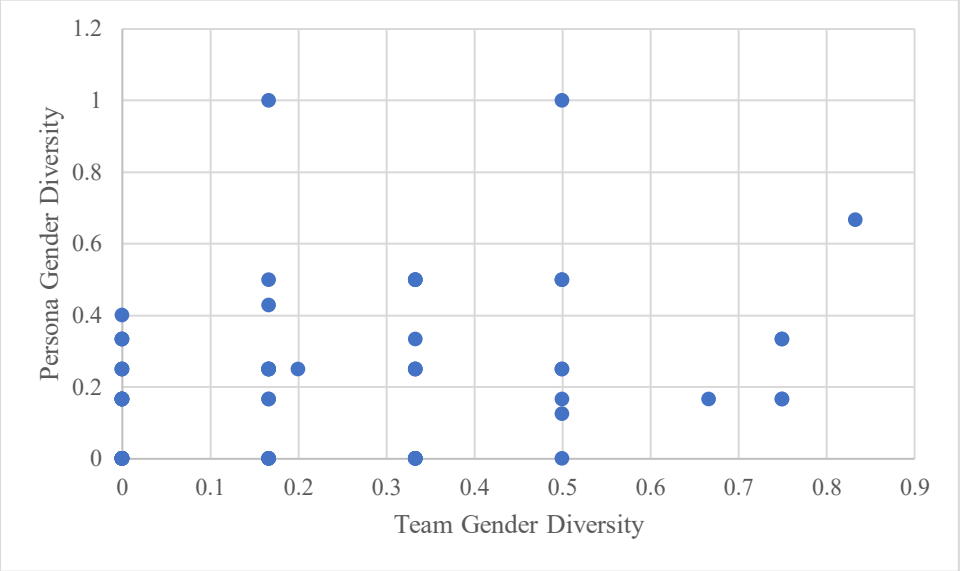
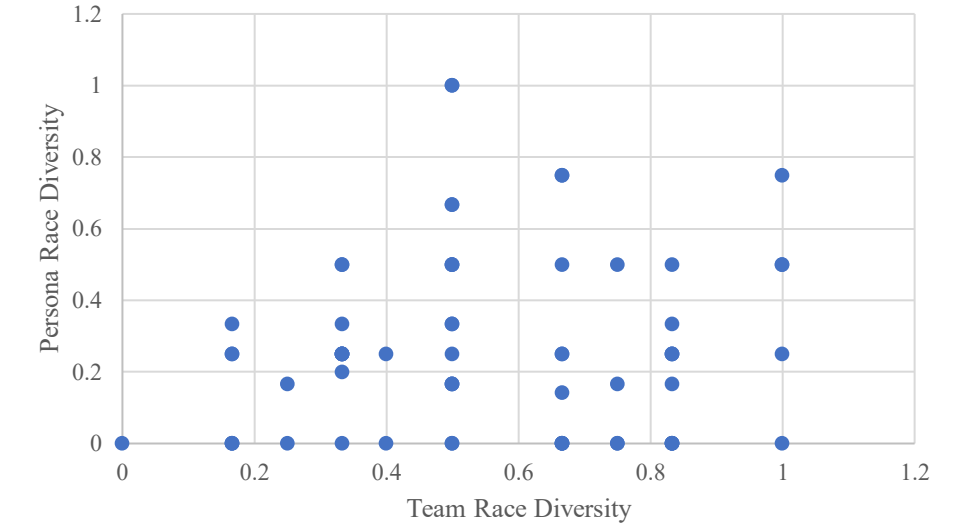


Figure 2: Race/Ethnicity Diversity, Team vs Fictional Persona (%)



Both the gender and race diversity within the team compared to the gender/race diversity of the personas created were found to have slight upward trends; however, there was no notable significance within these comparisons. As gender and race/ethnicity diversity on student teams increases, a slight increase in the diversity of the personas they create can be noted. In other words, more diverse student teams are more likely to create fictional engineering personas different from the white, male majority identities.

Discussion & Conclusions

Our exploration into the gender and racial/ethnic identities that first-year engineering students assign to fictional professionals that are both engineers as well as non-engineer members of a fictional collaborative team provide additional insights into the ongoing

explorations of US cultural and societal stereotypes and deeply held beliefs about who "is or is not" viewed as an engineer. We found that in the first-year engineering student population, the self-reported gender and race/ethnicity data to be divergent from the majority (white male) at a similar ratio to those of the national population of engineering students. Additionally, we found that their collective assignment of identities to their created personas divergent from the US engineering majority lower than the ratios represented within their own class's population and more closely related to what is represented in the US engineering workforce [12], [13]. Students most often assigned white and male identities to the fictional engineering professional personas, and upon exploration of the additional non-engineering team members (that varied from scientists in other STEM fields, to business managers, marketing specialist, factory workers, etc.) these were also not representative of the national population and were also assigned white and male identities. These findings are very much in line with Wendy Faulkner's theory of technical dualism that proposes that gender is divided and associates masculine instrumentalism with technology-focused traits and feminine expressiveness with people-focused traits [6]. The stereotypical picture of an engineering professional has historically been a cisgendered white male who has a greater than average knowledge of math, science, and technology [2], [6], and these stereotypes appear to still be present and pervasive through the results of this exploration. While research has consistently shown this to be true for younger populations of students [15], our results also point to the fact that these beliefs are still held by a population of college-age students all pursuing higher education engineering degrees.

We also explored the possibility of a relationship existing between the number of gender and racial/ethnic identities that were divergent from the majority represented on student teams with the number of gender and racial/ethnic identities that were divergent from the majority assigned to the fictional engineering personas. We explored this possible relationship as research in engineering education has indicated that increased exposure to mentors or peers with identities that challenge or defy the white male stereotype in engineering can be influential in improving the motivation for success and perceived fit for students with similar diverse identities [7], [15]. While our results indicated that there was a slight positive relationship between the number of gender and racial/ethnic identities that were divergent from the majority represented on student teams and the number of gender and racial/ethnic identities that were divergent from the majority assigned to the fictional engineering personas, it was not a notable significance.

While harmful stereotypes exist within engineering contexts for women and other underrepresented identities, there has been a lot of progress within the area as shown by the increasing number of minority students within undergraduate engineering programs [13]. There is still work to be done and understanding how gender and race-based stereotypes attached to engineers manifest for first-year engineering students is a first step in designing interventions to challenge and dispel those stereotypes and not let them persist past the first year in an engineering program. The purpose of this investigation was to determine whether undergraduate students tend to assign gender or racial identities to engineering professionals in line with the theory of technical dualism. The results suggested that while student participation within undergraduate engineering programs appears to be broadening in diversity, there appears to still be underlying beliefs about what gender, race, or ethnicities identities professional working engineers hold within the first-year engineering student population sampled for this work. This reinforces the need to continue work towards reducing the stereotypes against women and other underrepresented minorities within engineering programs and increase the exposure of students

to engineers who identify outside of the stereotypical gender and racial identity of an engineer in the US. Likewise, the results of this investigation suggest that increasing emphasis on fostering diverse teaming situations for undergraduate engineering students could be one way to broaden their perspectives of who “can and cannot” be an engineer.

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