Are Hardhats Required for Engineering Identity Construction? Gendered and Racialized Patterns in Canadian Engineering Graduates' Professional Identities

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Abstract

Despite ongoing efforts to increase diversity in engineering, women continue to be underrepresented in the field, making up only 15% of licensed professional engineers in Canada [1]. This persistent underrepresentation has been explained in part by the challenges women and other underrepresented groups face in identifying with engineering, including feeling inauthentic in traditional engineering roles, and doing additional work to manage impressions and demonstrate professional fit [2-4]. Studies on engineers' career paths have also shown that underrepresented groups in engineering are more likely to be streamed into non-traditional career pathways with less social capital, negatively impacting their identification with the field [5-8]. As identification with the profession can predict the persistence of both engineering students and professionals [9], there is a need to understand factors that influence engineering identity, and how these factors may vary by demographics. Using data from a 2022 national survey of engineering graduates (n=982), we examine the engineering intensity of participants' professional identities disaggregated by gender and race. Our findings reveal that role type, technical focus, and application of background education were salient themes across the entire sample, reflecting the prioritization of traditional and technically oriented work in engineering culture [10]. For engineering educators, understanding the factors that influence engineering identity has implications for their ability to foster their students' sense of belonging, encourage their retention in the field, and improve their access to a range of meaningful engineering career paths.

Literature Review

Our literature review looks at two bodies of research: engineering professional identity and engineering career paths. Within these bodies of literature, we looked for studies that foreground diversity, equity, and inclusion (DEI) in their analysis to understand how identity formation may vary for different race and gender groups.

Engineering Professional Identity

One way professional identity has been conceptualized in literature has been in terms of an individual's attributes. One's attitude toward their profession, their career anchors, and professional orientations have all been suggested as ways to understand professional identity [11-13]. These studies have centered individual level traits as being influential to an individual's identity formation, but fail to consider the influence of demographics and social influence. Other

studies on engineering professional identity consider DEI explicitly in their work, and comment on the impact of engineering culture on identity formation. For example, Cech discussed how two dominant ideologies in engineering culture – meritocracy and depoliticization – can reinforce social systems of disadvantage [14]. Meritocracy is the belief that rewards are distributed as a product of merit, talent, and hard work, as opposed to being a result of systems that impact access to opportunity. Depoliticization assumes that engineering is exclusively technical, and by extension exists outside of social influence. This results in the privileging of technical work over socially oriented work in engineering and fails to recognize its complexity and heterogeneity. In her 2007 ethnographic work, Faulkner describes this as a technical/social dualism in engineering, where technical identities are seen as more valid and desirable, and more closely aligned to the role definition of engineering [10]. This phenomenon creates an inaccurate conception of engineering as a purely technical profession. Faulkner additionally contributed several other key equity concepts, including "gender and professional in/authenticity," and the "in/visibility paradox", which highlight how the technical/social dualism in engineering works to reinforce gender roles and expectations [2]. She found these phenomena require women to do intensive identity work to continuously assert and re-make their identities in a masculine-typed organizational and professional culture. The burden of impression management on women in engineering was also studied by Hatmaker, who found women's professional identity formation is impacted by their interpersonal interactions at work [3]. Through their negotiation tactics with these interactions, women can influence culture change or sustain it, but that burden largely falls to them to change the environment to be more accepting and comfortable.

Gender norms can also impact career path realities for women, whether by intentional streaming or self-expressed career decisions. One example of this is Cardador's observation of an "inverted role hierarchy" in engineering [7]. She found that women in engineering were disproportionately tapped for management roles. Though this was originally intended as a strategy to retain more women in the profession, she discovered it ultimately had a negative impact on their perceptions of themselves as engineers. Given that management roles, particularly the administrative middle management roles many women find themselves in, are less desired by engineering culture than primarily technical roles, promoting women into these roles reduced their overall sense of belonging in the profession. In addition to the intentional promotion of women into these roles, Cech found that women also have a tendency to make self-expressive career decisions, choosing roles and paths that reflect broader gender roles and expectations [8]. This can reinforce the sorting mechanisms that lead increasing numbers of women in management to identify (and be identified) as less authentically engineers.

Engineering Career Paths

The increasing stratification of engineering career paths presents a challenge for researchers attempting to define and study engineering identity, as the definition of engineering is broad and

rapidly expanding. Sheppard et al. touched on this issue in their study of undergraduate engineers' occupational aspirations and their post graduate career path realities [15]. They cited a key challenge being the lack of one definition of what engineering is across datasets, making it difficult to ascertain who is, and who identifies as an engineer. Previous work by Tremblay et al. and Rottmann et al. defined a range of engineering career paths, finding that engineers are interested in and fill a variety of roles expanding beyond the traditional two-track career path model [16,17]**.** Despite the wide range of roles taken up by engineering graduates, not all career paths are considered equally legitimate in engineering culture, nor are they equally accessible to everyone. Several studies have shown that there can be negative consequences for those on less traditional career paths, who are also often underrepresented groups in engineering. For instance, Rottmann et al. analyzed the career paths of 29 senior engineers and found that women and racialized engineers were over-represented in career paths featuring winding, under-resourced paths to advancement [17]. A 1983 study by Lebold et al. found racially minoritized engineering graduates were more likely to be employed in non-engineering fields, with those remaining in engineering experiencing lower pay and more strained working conditions 10 years after graduation [6]. Adams' more recent (2017), Canadian study found that engineers' working conditions differed significantly by organizational position, class, race, gender, and location of training [18]. These studies reveal the material impact of career path stratification in terms of working conditions, mobility, and pay, particularly for underrepresented groups in engineering.

Engineering Identity and Engineering Education

The burden for underrepresented groups in engineering to navigate and assert their identities isn't a phenomenon exclusive to the workplace, but rather one that begins in school. Tonso's research on the gendered nature of identify formation in US-based engineering schools showed that women were implicitly excluded by peers from the campus identities most closely related to the prototypical engineering identity [9]. Dryburgh found similar results in a Canadian context, noting that female students were required to do additional work to manage impressions and demonstrate fit with engineering culture compared to their cis-male peers [4]. In her 2001 study of students in a Scottish university's engineering department, Walker identified the restricted range of engineering identities women take on — primarily those that legitimize, but in some cases, also those that resist engineering culture, echoing Hatmaker's findings that the burden primarily falls to women to either adapt to a hostile environment, or change it [19]. Chachra's work looked at engineering identity development in undergraduate programs as a key predictor of students' decisions to pursue and persist in engineering. They found female and male students identified with engineering to a similar degree, but identified different skills as being most important to engineering design [20]. The difference in identification with engineering skills suggests that social structures produce gendered norms that differentially shape the professional identity of men, women, and non-binary students. These studies demonstrate ways in which elements of engineering professional culture can make it challenging for underrepresented

groups to identify with engineering, starting in educational contexts. Further, given that engineering educators play a key role in shaping how their students understand definitions of engineering identity, it is critical for them to understand the factors that influence this process, and how it varies for different demographic groups.

Research Questions

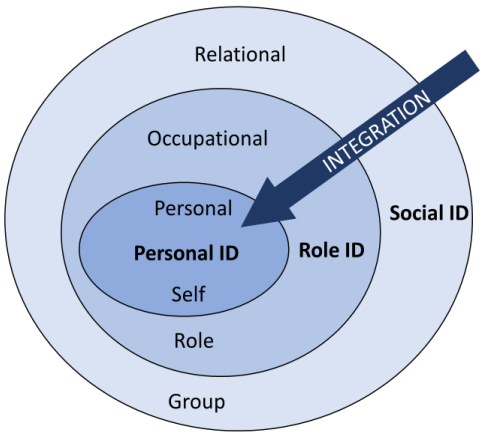
To help us understand the factors that influence engineering graduates' professional identities, our research questions for this study are as follows:

1. How central is engineering to the professional identities of engineering graduates in Canada?
2. What factors do engineering graduates identify as influential to their professional identities? How do these factors vary by race and gender?

Conceptual Framework

Our conceptual framework is made up of 3 identity theories: personal identity theory, role identity theory, and social identity theory [21-24]. These theories allow us to interpret the different ways in which the engineering graduates in our sample are narrating their professional identities. For the purpose of this study, we understand identity formation as a cognitive process, where one forms their identity through an exchange of information between oneself, their social interactions and the environment [25]. People tend to have varied awareness of this process, narrating their identities centering differing levels of agency. For example, an individual can understand their identity as character traits that are intrinsic to them (pure agency), versus viewing their identity in the context of social and societal influence. In Figure 1, as the theories move towards the innermost layer of the diagram, identity formation is viewed as more internal, personal, and agentic. As the theories expand to the outer layers, identity formation is viewed as more external, contextual, and influenced by structure.

Figure 1: Conceptual Framework – Identity at different levels of integration to self



Personal identity theorists view identity formation as an individual and agentic process, rejecting the idea of social influence on one's adoption of certain traits or values [21]. In the context of engineering identity, personal identity theory helps us understand engineering as a calling— with certain people naturally inclined to engineering work. In contrast, Stryker characterized identity as a role-based phenomenon [22]. In the context of engineering identity, role identity theory helps us understand engineering as a position defined by a series of responsibilities and duties. It helps us identify features that distinguish engineering work from other fields, and distinguish different types of engineering work from each other. Finally, Tajfel et al. characterize identity formation as a social process at the group level [23, 24]. Social identity theory helps us understand engineering as a social group that shares traits and values, and understand what it takes to be afforded insider status in engineering culture.

An individual can process and integrate external stimuli into their identity on each of these levels. For instance, consider a woman engineer who has just been tapped for a managerial rather than technical promotion. She may interpret this experience at a personal level, crediting this promotion to her being personally skilled at managing people or not being naturally oriented to technical work. Alternatively, she may view this experience through a role identity lens, claiming the identity of a manager as it is now her formalized position and no longer feeling like an engineer upon leaving a technical role. Finally, she may view this experience through a social identity lens, either feeling fortified in her engineering identity through her promotion and the recognition of her engineering leadership by her peers, or an erosion of her engineering identity when her career track and sociotechnical skillset is compared with "nuts and bolts" engineers who graduated from her program. In our analysis, we will use these theories to identify and interpret the different ways in which engineering graduates across an intersectional gender/race variable understand their professional identities and the factors that influence them.

Research Methods

Data & Variables of Interest

This study uses data collected from a larger project titled "More than Recruitment & Retention: Tracking Inequity in Engineers' Career Paths". Data for the project was collected through a 69-question cross-Canada survey recruiting engineering degree holders in Canada who completed their undergraduate studies prior to 2013. The survey was distributed by the Troost Institute for Leadership Education in Engineering at the University of Toronto, in partnership with Engineers Canada. All provincial and territorial engineering regulators were invited to participate, 8 regulators and one advocacy organization agreed to either distribute the survey to their membership or post links on social media. Additionally, participants were recruited to participate through the University of Toronto's alumni office network and social media, as well as through Women in Science and Engineering (WISE), and the National Society of Black Engineers

(NSBE) Canada. In total, our survey ended with a sample size of 982 respondents. Of our sample, 24% identified as women, 12% identified as racialized, and 85% were licensed as Professional Engineers. Compared to the national average, women and licensed engineers are overrepresented in our sample. According to Engineers Canada 2023 National Membership report, women make up 15% of the total membership in the profession, and it is estimated that between 38-44% of engineering graduates proceed to licensure [26]. We are unable to compare our sample to population level data for race, as this data for both racialized engineering graduates and professionals currently does not exist in Canada.

Quantitative Analysis

We used descriptive and inferential statistics to analyze participant responses question Q60: *"On a scale of 1 to 10, please rate the centrality of engineering to your professional identity."* For inferential analysis, we used the Kruskal-Wallis test to determine if there were significant differences in identity ratings by demographic variables, licensure status, and career paths. We selected this specific non-parametric test because we were comparing more than three groups on an ordinal variable (engineering identity). For demographic variables, we choose to use an intersectional gender/race category made up of: racialized women (RW), white women (WW), racialized men (RM), and white men (WM). Though we did collect more detailed race data, the number of racialized respondents (particularly racialized women) were too few to draw patterns across individual ethnic or racial categories. Similarly, though non-binary was given as an option for gender on the survey, the number of non-binary or gender non-conforming respondents were too few to include as a discrete category in our analysis.

Qualitative Coding Process

To gain a deeper understanding of why respondents gave the identity ratings they did, we then conducted qualitative analysis on survey question Q61, an open-ended question that asked respondents to explain their identity rating in Q60. In total, we coded 663 responses to Q61. We started by using an inductive coding process to describe emergent themes in the data [27]. For the next stage of our coding process, we revisited the responses to Q61 through a more deductive process, coding them through our theoretical framework made up of three identity theories [28]. Throughout our inductive and deductive coding processes, we used the constant comparison method to iteratively sort codes into groups in relation to key themes [29]. For our final stage of analysis, we examined the four gender/race groups for prominent themes and codes.

Findings

Quantitative Analysis Results

We received a total of 934 responses to Q60, with 663 respondents also completing Q61. Overall, we found that engineering was central to participants' professional identities. Identity ratings in the sample were very high with a mean rating of 8.2/10. 85% of respondents rated a 7/10 or higher, with 33% of respondents rating a 10/10. Kruskal-Wallis tests were conducted to evaluate differences in median identity ratings among the four gender/race categories, age category, career path, and licensure status. A summary of statistical results can be found below in Table 1. Using these tests, we found identity ratings varied significantly by age category, career path, and licensure status. Through further analysis using pairwise comparisons, we saw those on technical paths gave higher ratings than those on non-traditional paths. We also found those who held professional licenses gave higher identity ratings than those who experienced barriers or were unable to get their experience recognized.

Table 1: Results of Kruskal-Wallis Tests Comparing Median Identity Ratings across Several Variables

Variable	**H**	**df**	**N**	**p**
Gender and Race Racialized women White women Racialized men White men	4.07	3	858	*n.s.*
Age 30 to 45 years $_{a,b}$ 46 to 65 years $_{a}$ 66 years and over $_{b}$	19.97	2	925	<0.001
Career Path Technical specialist $_{a,b,c}$ Executive track $_{c,d}$ Boundary spanner $_{b,e}$ Entrepreneur $_{e,f}$ Non-traditional path $_{a,d,f}$	74.52	4	901	<0.001
Licensure Status Licensed Professional Engineer $_{a,c}$ Not licensed, but intends to be $_{b}$ Not licensed, and has experienced barriers $_{c}$ Not licensed, and feels it is unnecessary $_{a,b}$ Previously licensed, now retired	44.87	4	934	<0.001

Note: Same subscript under each variable denotes significant post-hoc pairwise comparison to $p<0.05$

Though the difference in median identity rating was found to be insignificant between our four gender/race categories, we can observe some other differences between the groups. Using a Kruskal-Wallis test we found a significant difference in belonging ratings between groups,

finding H (3, N=867)=18.978, p<0.001. Similarly, we found a significant difference in graduation year between our race and gender groups, finding H (3, N=909) = 99.825, p<0.001. Table 2 below provides a descriptive summary of the subsample of respondents (n=663) who provided a response to the open-ended question. In this group, we observed that the white men in the subsample graduated on average 13 years prior to the racialized women.

Table 2: Summary Characteristics of Sample by Race and Gender

Variable	**Engineering Graduates by Race and Gender**				
	RW (*n*=27)	**WW** (*n*=132)	**RM** (*n*=152)	**WM** (*n*=409)	**Sample** (*n*=663)
Mean Identity Rating (/10)	7.8	8.3	8.0	8.3	8.2
Mean Belonging Rating (/10)	6.2	7.2	7.8	7.7	7.5
Mean Graduation Year	2003	1998	1997	1990	1993
Licensure Status	69% licensed, 22% experienced barriers to licensure	86% licensed	71% licensed, 15% unable to get experienced recognized	92% licensed	85% licensed

In our inductive coding process, we initially coded all 663 responses and pulled out key themes. Recognizing the impact that age and time spent in the field can have on identity development, we then choose to replicate this analysis controlling for age, including only respondents who graduated in the last 20 years (1994 or later), reducing our sample to 311 responses. Interestingly, after controlling for age we found that the themes articulated by the individual race and gender groups were consistent with those that emerged when all age groups were included. Given this, we decided to include all 663 respondents in our final analysis, in order to include more voices of racialized men who had been reduced from 152 to 30 respondents when only the younger group was included.

Qualitative Coding Results

A total of 663 respondents completed Q61. During our coding process, we found that many open-ended responses had several parts, often with one response indicating both circumstances that increased and decreased the centrality of the respondent's engineering identity (for example, *"I am very technical* ***but*** *my career aspirations are no longer within engineering*). To accommodate the presence of multiple semantic units within each response, we assigned multiple codes to many responses, resulting in 1,075 codes in total, with an average of 2 codes per response. A summary of how codes break down by identity theory can be seen in Table 3 below.

Table 3: Percent of Respondents in each Gender/Race Category with Identity-Based Codes

Code	RW (n=27)	WW (n=132)	RM (n=152)	WM (n=409)	Sample (n=663)
Personal ID Theory	30%	23%	23%	22%	23%
Role ID Theory	59%	72%	69%	68%	70%
Social ID Theory	37%	31%	27%	26%	27%

As seen in Table 3, the majority of survey respondents (70%) explained their identity ratings in ways that related to their roles, invoking role identity theory. This included listing job titles, describing the duties or responsibilities of their roles, or the qualifications required for them to have those roles. Some people also qualified the type of work they do in their roles, such as it being technical or managerial. Codes relating to role identity make up the majority of codes for every race and gender group, though racialized women had a lesser proportion of codes in this category compared to the other 3 groups (at only 59% compared to 70%).

23% of survey respondents explained their identity ratings in ways that related to their personal preferences and character, invoking personal identity theory. Many of these respondents spoke about their personalities, and whether or not they thought they were naturally inclined to engineering. Some people also shared where engineering fit into their overall personal identity, either as a central part or one that was less salient compared to other identities. Racialized women had a greater proportion of codes in this category than other groups, with 30% mentioning a code in this category (compared to the sample average of 23%).

27% of survey respondents explained their identity ratings in ways that related to their social groups and how they relate to others, invoking social identity theory. This included talking about how the perceptions of others impacted their career, their sense of belonging in engineering, or how they work with others. Racialized women also had a greater proportion of codes in this category than other groups, with 37% mentioning a code in this category (compared to the sample average of 27%).

Key Themes: Full Sample

Through our initial inductive coding process, we found that some themes were salient for all race and gender groups. Echoing the findings above, these codes primarily reflected role identity theory, falling into themes of: 1) Traditional role/organization type; 2) Technical focus; and 3) Application of background education. Gender, race, and identity rating on a 10-point scale (IR) are indicated for each illustrative quote provided.

Theme 1: Traditional role/organization type

One way the engineering graduates in our sample explained their engineering identity rating was in relation to having a traditional engineering role. Some respondents described what type of role they are in, or the type of work that they do. For many of the respondents with these types of roles, there was no question of their engineering identity – for example, one man noted: "*I have been doing engineering for oil companies, nuclear power plants, nuclear reactors, driverless subway system designers, if I [do not do] engineering, who does!?" (RM, IR:10/10).* Other respondents described working in an engineering company, such as one woman who said: *"The company I work for is a very specialized engineering consulting company, unique and arguably the best in the world. I am very proud of the company we have grown into over the 28 years I've worked there." (WW, IR:10/10).*

Several respondents also explained their identity ratings as contrasting with traditional engineering roles. In some cases, these respondents expressed that they no longer work in the engineering field: *"I am in the legal field and not currently working as an engineer. (RW, IR: 1/10).* Despite no longer working in engineering, some of these respondents still felt connected to an engineering identity, such as this physician who shared: *"As a physician, engineering is less central to my identity in daily clinical practice. However, on a personal level, it shapes my approach to clinical practice and administrative work" (RM, IR: 6/10).*

Theme 2: Technical focus

In addition to those who spoke about holding traditional engineering roles, many respondents connected their engineering identities to the technical nature of their work. These respondents spoke about doing technical or design work, being in technical roles, and valuing technical problem-solving. Some respondents went the extra mile to assert that they were *exclusively* technically oriented. For example, one woman stated: *"I have always worked in technical fields with technical people. It has always been central to the culture in which I worked and the nature of the work that I do." (WW, IR: 10/10).* Others expressed that they had no interest in any work that was of a non-technical nature, and a distaste for management-related work. One man shared: *"I remained in the technical side of engineering for most of my career. Middle-management sucks!" (WM, IR: 10/10).* Another man described returning to a technical role after briefly being in management, saying: *"Throughout [my] career, [I] progressed to senior manager positions but changed roles about 5 years ago to Reliability Engineering to be more "hands on" with technical engineering work rather than administration positions. A lot more fun dealing with equipment issues all day than managing people." (WM, IR:10/10).*

Several respondents, often with lower identity ratings, explained that they felt less like "real" engineers due to their work being non-technical. One man shared: *"My current position isn't*

really an engineering position. It's primarily spreadsheet work (I.e. no actual design, testing)." (RM, IR:5/10). Similarly, another man explained his identity rating in relation to his involvement with design activities: "*My position as a maintenance engineer is mainly one of an investigator/problem solver. I have little involvement with design or engineering calculations." (WM, IR:6/10).* Other respondents expressed a distance from a technical identity due to their involvement in management work, such as one woman who shared: *"I am more involved in management roles than I am involved in technical roles" (WM, IR:8/10).* The high representation of these codes demonstrates the persistent and strong connection in our sample to the technicist "nuts and bolts" engineering identity [10] – both for those who feel they embody that identity and for those that don't.

Theme 3: Application of Background Education

Many respondents made connections between their undergraduate education and engineering identities, such as one woman who explained: *"My professional identity is being an electrical engineer, that's what I studied in school, that's what I practice at my profession." (WM, IR:10).* Similarly, another man put it simply: "*I studied engineering and I practice engineering, so engineering is central to my professional identity." (WM, IR:10/10).*

Other respondents talked about applying an engineering mindset or approach. One man shared that he brought this mindset to everything: *"I bring an engineer mindset (problem solving, optimization) to everything I do." (WM, IR: 10/10)*. This was especially true for those in less technical or traditional roles, who said they used their engineering mindset and problem-solving approach regardless of the nature of their work. One woman in a non-technical role shared: *"I almost always introduce myself as an engineer and I feel as though I apply an engineering mindset to most of my work even if it is non-technical" (RW, IR: 9/10).* Another woman asserted that her mindset was valued by her workplace: "*Although I do not use my technical background as an engineer, my workplace values "the way I think" as an engineer (analytical, big picture)" (WW, IR: 5/10).* Similarly, one man shared that his engineering mindset made him unique in his field: *"Being technical and educated as an engineer makes me special in marketing and gives me a different perspective from most. (RM, IR: 4/10)".* These quotes demonstrate the role of engineering education in engineering identity formation, as many engineering graduates connect their identities to the application of what they were taught in school.

Key Themes: Gender/Race Groups

In the following section, we explore how key themes were differentiated by gender and race groups. Though there were many similarities in themes between groups (as discussed above), there were also themes that emerged uniquely or were represented differently by gender and race. A summary of the key themes by group can be found in Table 4.

Table 4: Summary of Key Codes by Gender/Race Groups

Gender/Race Group	Key Codes
Racialized Women	1) Engineering is my calling 2) I work with engineers 3) Others know me as an engineer 4) Low representation of technical focus
White Women	1) I am proud to be an engineer 2) I am a professional engineer 3) Being an engineer is proof of my credibility
Racialized Men	1) I am what I do 2) Engineering is core to everything 3) Others know me as an engineer
White Men	1) I have experienced success in engineering 2) Engineering is part of my identity but not all 3) I am not proud to be an engineer

Racialized Women (n=27)

More than any other group, the racialized women in our sample articulated factors impacting their identity relating to personal and social factors. Four themes emerged as particularly salient: 1) Engineering is my calling; 2) I work with engineers; 3) Others know me as an engineer; and 4) Low representation of Technical Focus codes.

Theme 1: Engineering is my calling

Several of the racialized women in our sample narrated their identity ratings in ways relating to their personal traits. These women asserted that they were "meant to be" engineers, such as one woman who said: *"Being an engineer is core to who I am and very important to me. It's akin to a calling, more than a career" (RW, IR: 9/10).* Similarly, some women put this in the context of having engineering personalities. One woman shared that she thought she had the traits of a "typical engineer": *"I feel that a large part of my personality can be attributed to a "typical engineer' – practical and logical." (RW, IR: 7/10).* Another respondent viewed this inclination to engineering as being a "way of life", saying: "*I view engineering as a way of life. The way that I respond to any problem, whether work-related or personal, is very similar and methodical. (RW, IR: 8/10).* For these women, engineering identity is highly personal and central to their sense of self – so much so that they consider their engineering identity to be a natural disposition, and core to how they experience life around them (professional and otherwise).

Theme 2: I work with engineers

Racialized women also spoke about working with other engineers. Some of these women spoke about supervising other engineers – understanding their needs or being in close proximity to their

work on a day-to-day basis. For example, one woman shared that her engineering background helps her support the team she manages: "*Engineering is at the foundation of what I do, even as someone in the management side of the business – I find it essential to maintain technical knowledge of what my team is doing, to be able to better support their needs and understand their day-to-day issues" (RW, IR: 8/10).*

Other women spoke about working with others in terms of relating to engineers. For example, one woman shared: "*Even though I don't technically work as an "engineer", I still think of myself as that. Possibly because I work in Higher Ed, so there are engineering students around who I feel a kinship to!" (RW, IR: 10/10).* Similarly, another woman stated: *"I am not practicing engineering but could relate to engineers I support." (RW, IR: 4/10)*

Theme 3: Others know me as an engineer

These women also touched on the impact of others' perceptions on their identification with engineering. One woman shared that her identity as an engineer was helpful for others in her life to understand her: "*It is easier for people (family, friends and clients) to relate to." (RW, IR: 10/10).* Another woman asserted that her identity as an engineer was actually more important to others than it was to her: "*Engineering is more significant to how others view me than how I view myself. I identify strongly but not solely with being an engineer... I now see myself more as a leader, a manager, a steward of the public good, a working parent of two children, and not just as an engineer." (RW, IR: 7/10).*

Theme 4: Low representation of Technical Focus codes

Though codes relating to a technical focus were salient across the entire sample, racialized women were underrepresented in this category. No racialized women mentioned being in a technical role, though several mentioned being in non-technical roles. When the racialized women in our sample spoke about technical focus, they spoke about maintaining their identities despite being in non-technical roles, particularly by using their engineering mindset. For example, one woman who shared: *"While my current role is non-technical, I still use my engineering problem solving methodology in all aspects of management/strategy work. (RW, IR: 7/10).*

White Women (n=132)

The white women in our sample had a greater focus on themes relating to the profession itself and belonging within it. Three themes emerged as particularly salient: 1) I am proud to be an engineer; 2) I am a professional engineer; and 3) Being an engineer is proof of my credibility.

Theme 1: I am proud to be an engineer

One theme that emerged as salient for the white women in our sample was that of pride. These women articulated being proud to be engineers— to have completed engineering degrees, to hold engineering licenses, and to be in engineering roles. One woman expressed this pride in terms of her accomplishments, as well as the profession itself: ***"****I am proud of my achievement of attaining my P.Eng. designation and the hard work that I did in my educational studies and career over the past 13 years. I believe that engineers make a positive contribution to society daily and this brings me professional fulfillment. (WW, IR: 9/10).* Some also spoke about being proud of engineering culture and participating in its rituals. In the quote below, this woman mentions wearing her iron ring – a Canadian engineering tradition where graduates receive an iron or stainless-steel ring as a symbol of their social responsibility as engineers: *"I wear my iron ring proudly and always advocate for my profession (WW, IR: 10/10)".*

Theme 2: I am a professional engineer

More than any other group, white women explained their identity ratings in ways relating to their professional status. These women spoke about holding their professional designations, such as one woman who stated: *"I am a professional engineer. I stamp documents. (WW, IR:10/10),* or another who wrote similarly *"I use a seal in my work, and sign communications with P.Eng. (WW, IR: 10/10).* Other women spoke about licensure in the context of whether it was required by their employer for their current roles. Women in this group mentioned both instances where their license was required as well as those where it wasn't. One woman mentioned her license having value even in a role where it wasn't required, sharing that "*Working in the environmental field, the 'engineering' designation carries a certain weight over other enviro professionals, so I do identify with it and include it in my email signature, etc. It's a requirement for my current role, mind you, but [for] my previous position [it] wasn't." (WW, IR: 7/10).*

Theme 3: Being an engineer is proof of my credibility

White women also spoke about engineering being proof of their credibility, and its significance to being respected by others professionally. One woman shared that this was particularly important given her gender, saying: *"P.Eng. creates a good first impression and demands some respect especially as a female." (WW, IR:7/10).* This was especially relevant for women who articulated no longer being in roles that required a professional designation, but found it useful to garner the respect of their colleagues. Another woman wrote: "*I don't need to be an engineer to do my current work, but it helps give me more weight when I am talking to colleagues/managers or students when I recommend something. I feel like I get more respect by them knowing what I have accomplished in the past in my engineering work. (WW, IR: 5/10).*

These themes demonstrate a strong connection between professional culture and engineering identity for white women. Whether by obtaining a professional license or participating in engineering cultural practices, feeling a sense of membership in the profession is important to these women's professional identities. Further, it is important to have that sense of belonging validated by peers, through having their credibility recognized and respected.

Racialized Men (n=152)

Three themes differentiated the racialized men from other groups in our sample: 1) I am what I do; 2) Engineering is core to everything; and 3) Others know me as an engineer.

Theme 1: I am what I do

Though codes relating to traditional engineering roles were salient for all groups, racialized men in particular asserted that engineering is what they do, and further that they *are* what they do. One man put this elegantly as: *"As Aristotle put it "you are what you repeatedly do"." (RM, IR: 10/10).* The men in this group at times answered this prompt in ways that almost seemed to imply their responses should have been obvious. One man said simply: *"It's what I do." (RM, IR: 9/10).* Another wrote: *"I am a practicing engineer and that is how I identify myself so engineering is central to me and my career and my identity (RM, IR: 10/10).* These responses (in addition to their corresponding high identity ratings) project a high confidence in engineering identity, and a clear connection between identity and role description for racialized men.

Theme 2: Engineering is core to everything

The racialized men in our sample also spoke about engineering being central to everything in their lives. One man wrote, *"All what I do, think or achieve is somehow Engineering" (RM, IR: 8/10).* One man connected this to his value of problem solving, with one man saying: *"Problem solving and engineering has always been a part of my life. It is something I hold a lot of value to." (RM, IR: 8/10).* One man went as far to say that not only was engineering core to everything, but that it had always been. He wrote: "*I was born an engineer and that is all I ever did – even as a child."* (RM, IR: 10/10). These responses demonstrate a high integration of engineering into the personal identities of racialized men. Similar to racialized women, engineering is articulated as being core to the sense of self of the racialized men in our sample, impacting the way they see the world around them.

Theme 3: Others know me as an engineer

Similar to the racialized women in our sample, the racialized men also articulated that engineering was significant to how others saw them. One man described being known by others

as an engineer saying: "*I am passionate about my work and the positive effects it has. I talk about it all the time, and most people in my circles know I am an engineer and my industry" (RM, IR: 10/10).* Another man described his reputation as an engineer as being connected to his skills and knowledge: *"I am a trusted technical advisor and valued for my analytical thinking skills that people see as attributes of an engineer." (RM, IR: 8/10).* One man in the sample similarly described engineering as important to how others saw him, connecting it to the expectations of his role. He said *"I have Engineering in my title. People expect that I am an engineer." (RM, IR:10/10).*

White Men (n=409)

Three themes differentiated the responses of white men from the other groups in our sample: 1) I have experienced success in engineering; 2) Engineering is part of my identity but not all; and 3) I am not proud to be an engineer.

Theme 1: I have experienced success in engineering

More than other groups, white men discussed having experienced professional success in engineering. Some expressed this in terms of pride, with one man saying: "*I'm proud of my profession and personal achievements in this area." (WM, IR: 8/10).* Others expressed these successes in terms of receiving external recognition from their organizations, or by being the best in their field. One man shared: *"I bring a lot of clout to the organization I work for. My unique skills and level of industry understanding help to set us apart from our competition. We have been able to continue to service our clients (I would like to think) because of my expertise." (WM, IR: 10/10).* Similarly, another man connected his engineering identity to his achievements by saying: *"I'm the top dog in distribution powerline design" (WM, IR:10/10).*

Theme 2: Engineering is part of my identity but not all

More than any other group in our sample, white men spoke about having heterogenous identities. These men spoke about engineering being only one part of their identity – referencing their other interests and roles as being important as well. One man shared: *"It's a strong side of my identity, however not central – there are other aspects of who I am." (WM, IR:7/10).* Another put simply: *"I am an engineer, but I am other things as well." (WM, IR: 8/10).* In some cases, these men also made a distinction between their professional and personal identities, asserting that despite engineering being something they do, it is not who they are. One man commented: "*I feel that people should have other interests and enjoy other aspects of life, and have other things they identify with, and not just their job." (WM, IR: 7/10).* Similarly, another man said: *"I'm proud to say I'm an engineer but it does not rule my life" (WM, IR: 6/10).*

Theme 3: I am not proud to be an engineer

Though making up a small proportion of the overall responses, a few white men spoke about feeling a lack of pride for being in engineering. In some cases, this was expressed as criticism of the professional bodies. In others, it was expressed as a criticism of engineering culture, with one respondent naming a culture of "destructive elitism" in how engineering is treated in Canada. In one response, a man criticizes the regulators but also refuses to participate in the tradition of wearing an iron ring – rejecting a Canadian engineering cultural practice. He says: "*Professional engineering sounds interesting, but in practice it has mutated into the realm of farce. The regulators are just bureaucrats that have no real ethics – despite pretending to value ethics. They are indistinguishable from politicians and more than willing to harm the public for personal gain. I refuse to wear my engineering ring – it is an embarrassment." (WM, IR: 1/10).*

Discussion

Our quantitative results tell us a few things. Firstly, we found that engineering is highly central to the professional identities of engineering graduates in our sample. This can be explained, in part, by our recruitment strategy. Because of our decision to deliberately diversify the sample beyond our Toronto/Ontario base, we partnered with Engineers Canada and regulatory bodies. This improved our regional diversity but resulted in an over-representation of licensed engineers. Perhaps related to this sampling strategy, 40% of respondents identified being on a technical specialist career path. Our finding that identity ratings varied with both licensure status and career path (with those who were licensed and technically oriented having higher ratings) further contextualizes the high identity ratings in the sample. By breaking these findings down by our intersectional gender/race variable, however, we fleshed out differentiated responses by social location. Further analysis on how factors that influence identity formation vary by career path presents an area for future work.

Our coding process revealed that Canadian engineering graduates' engineering identities are primarily role based, with the majority of responses invoking role identity theory. Across the sample, there was high representation of codes relating to being in traditional roles, having a technical focus, and applying an engineering background education. These themes demonstrate the persistence of the technical/social dualism in engineering, with the graduates in our sample closely tying their engineering identities to their proximity to a traditional "nuts and bolts" technicist engineering identity [2, 10]. Not only was this significant for those that asserted being in a technical or traditional role but was equally significant for those who justified lower identity ratings by explaining their distance from technically oriented work. In some cases, the technical/social dualism was particularly clear where respondents (both men and women) listed their resistance to management work as a qualifier for their high engineering identity, suggesting that those who do more socially oriented work are perceived as less authentically engineers. This can also be seen reflected directly in many responses from those who *were* employed in

management roles – citing their distance from "pure" engineering work as a reason for their lower identity ratings. The persistence of this exclusively technical engineering identity is both limiting and problematic. In reality, engineering identity is much more expansive and heterogeneous, and it is not only possible for engineers to retain both social and technical identities, but necessary [30]. As part of the Washington Accord, all accredited engineering programs in signatory countries (including Canada and the United States) need to demonstrate that graduates possess a set of attributes, which are not exclusively technical [31]. Teamwork, communication skills, and leadership skills such as project management are listed as key competencies for engineering graduates. The ways that graduates in our sample devalue some of these skills to justify their engineering identities suggests there is more engineering educators can do to emphasize the importance of socially oriented skills in engineering —and how their integration with technical skills is a key element of engineering practice, ideally helping them foster a socio-technical engineering identity.

By examining responses shared by racialized women, racialized men, white women, and white men separately, we were also able to demographically contextualize engineering identification processes. For example, the engineering identities of racialized men and women were highly personal. Several racialized women articulated that for them engineering was a calling, while several racialized men expressed that engineering was core to everything. The prevalence of these codes, contextualized by lower licensure rates and overall low representation of these groups in the sample and the engineering profession suggest that a high internalization of engineering identity may support persistence in the profession. Despite structural barriers, these engineering graduates assert their engineering identities as confident and intrinsic. This aligns with findings from a 2022 study by Chan et al., who found that older BIPOC graduates had much higher engineering identity than other groups, suggesting high identity was necessary for their persistence in the field [32]. Similarly, a study by Radebe et al. found that racialized women who rated high levels of belonging in engineering cited their own internal cultivation of that sense of belonging as reason for it, as opposed to receiving external social validation [33].

In contrast, we saw themes for white women that strongly invoked social factors, particularly relating to the profession at large. White women connected their engineering identities to pride in the profession, their licensure status, and the perceptions of others (particularly relating to their credibility). While these women expressed some challenges garnering respect from their colleagues, they primarily validated their engineering identities through their sense of belonging in the profession. Further still from the high integration of engineering into the personal identities of our racialized respondents, we saw that white men in our sample were more likely to express having heterogenous identities, claiming that engineering was part of their identity but not all. This was initially surprising given high licensure rates among white men, as well as their low representation on non-traditional career paths. In part, the ability for white men to simultaneously express multiple parts of their identities in professional settings may actually be

explained by the unquestioned technical nature of their roles. Given that they are underrepresented on non-traditional paths, it may be easier for these men to express other elements of their identities when their roles are primarily traditional, compared to others in non-traditional roles who may feel more pressure to assert their technical orientation to defend their engineering identities. Additionally, the ability to express heterogenous identities is reflective of Eagly's role congruity theory, and what Faulkner called gender in/authenticity [2,34]. As engineering is a male dominated and male typed field, other elements of identity that align with masculine gender norms are safe to be expressed. For example, while it may be hard for a woman to express her identity as a mother in a professional engineering setting for fear of being perceived as "too feminine" and therefore insufficiently masculine to be an engineer, a man is safer to express his identity as a father. A man therefore can comfortably hold his identity as an engineer and as a father simultaneously in his professional environment. Similarly, whiteness provides an additional dimension of privilege. Given this, it makes sense that the white men in our sample may feel that engineering is only a piece of their overall identity while still feeling included in the profession. Patriarchal society and masculine-typed engineering culture affords them the privilege to authentically express other parts of their social identities in an engineering environment with limited risk of exclusion.

Significance and Limitations

The main limitations of this study lie in the demographic makeup of the respondents. Our partnership with Engineers Canada and the provincial and territorial regulatory bodies improved our regional diversity, but also resulted in an over-representation of licensed engineers—85% of our sample compared to 30% of engineering graduates as a whole. Perhaps related to this sampling strategy, participants were more likely to be on the two traditional career paths—technical specialist and managerial, and more likely to identify with a technicist version of engineering identity. As a result, we were unable to capture as many respondents pursuing non-traditional pathways, or who may have left the engineering field altogether and no longer had relationships with their provincial or territorial regulatory bodies. Given the overrepresentation of marginalized groups along non-traditional pathways, we miss a key part of the picture in our inability to listen to these voices. The majority of survey respondents, not unlike the majority of licensed engineers in Canada, are white men (making up 409/663 responses to the professional ID question). The small number of racialized respondents limited our ability to break down race into specific racial/ethnic groups, and similarly the small number of gender non-conforming respondents limited our ability to transcend a gender binary. To learn from the experiences of those we were unable to capture in our survey, next steps will involve qualitative interviews with demographically under-represented groups. This will help us understand the experiences of engineering graduates with a wider range of professional identity ratings.

Conclusions & Recommendations

Our findings demonstrate the value in performing qualitative analysis of open-ended responses in large scale, cross-national surveys. They also highlight the importance of explicitly foregrounding DEI in the study of engineering identity. The use of a large-scale survey provided us with a broad snapshot of variables influencing engineering identity, but our coding process allowed us to see engineering professional identity as multifaceted and complex. Even within individual responses, many people listed multiple factors that impacted their identities, and often both those that increased and decreased the centrality of engineering to their professional identities. We also observed differences in factors by race and gender in our qualitative analysis, gaining perspective on factors that may differentially impact persistence in the field. Our coding process provided context we were unable to glean from the identity ratings or quantitative analysis alone— which on their own paint a simple picture of high identification with engineering across the entire sample.

Our findings suggest that nuts-and-bolts identities tied to traditional engineering roles, work, and mindsets remain as durable in Canada in 2022, as they were at the beginning of the century in Faulkner's ethnographic work in the UK and US. There is clearly more work to be done to educate future engineers on the value, and unavoidability, of socially oriented work. Engineering educators play a key role in fostering engineering identity development and must do more to encourage students to embrace sociotechnical identities. This is not only in alignment with the graduate attributes required by national accreditation bodies, but also reflects the heterogeneous nature of engineering work, simultaneously responding to demand from industry for engineers in a variety of non-traditional and multi-disciplinary roles. Additionally, encouraging expansive engineering identities beyond the stereotypical technicist identity will help to decouple definitions of engineering identity from gender norms, creating space for all engineers to be able to bring their full selves to work and school, regardless of their race or gender.

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References

[1] Engineers Canada, “2023 National Membership Information,” Ottawa, 2023. [Online]. Available:https://engineerscanada.ca/reports/2023-national-membership-information#-sex-representation-in-engineering

[2] W. Faulkner, Doing gender in engineering workplace cultures. II. Gender in/authenticity and the in/visibility paradox, Engineering Studies, 1:3, 169-189, 2009, https://doi.org/10.1080/19378620903225059

[3] D.M. Hatmaker, Engineering Identity: Gender and Professional Identity Negotiation among Women Engineers. Gender, Work & Organization, 20, 382-396, 2013, doi:10.1111/j.1468-0432.2012.00589.x

[4] H. Dryburgh, Work Hard, Play Hard: Women and Professionalization in Engineering—Adapting to the Culture. Gender & Society, 13(5), 664–682, 1999 https://doi.org/10.1177/089124399013005006\

[5] C. Rottmann, E. Moore, D. Reeve, A. Chan, M. Maljkovic, and D. Radebe. "Penalized for Excellence: The Invisible Hand of Career-Track Stratification." 2021 ASEE Virtual Annual Conference Content Access. 2021.

[6] LeBold et al, The new engineer: Black and White, male and female. Paper presented at the American Educational Research Association, Montreal, QC, 1983

[7] M.T. Cardador, Promoted up but also out? The unintended consequences of increasing women’s representation in managerial roles in engineering. Organization Science, 28(4), 597-617, 2017

[8] E. A. Cech, The Self-Expressive Edge of Occupational Sex Segregation. American Journal of Sociology, 119(3), 747–789, 2013, https://doi.org/10.1086/673969

[9] Tonso, K.L., Engineering Identity, in Cambridge Handbook of Engineering Education Research, A. Johri and B.M. Olds, Editors. 2014, Cambridge University Press: Cambridge. p. 267-282.

[10] W. Faulkner, Nuts and Bolts and People' Gender-Troubled Engineering Identities. Social studies of science, 37(3), 331-356, 2007

[11] S. Kerr, M.A. Von Glinow, J. Schriesheim, Issues in the study of “professionals” in organizations: the case of scientists and engineers. Organizational Behavior and Human Performance, 18, 329–345, 1977

[12] A.W. Gouldner, Cosmopolitans and locals: toward and analysis of latent social roles-1. Administrative Science Quarterly, 281–305, 1957

[13] E.H. Schein, Career anchors: Discovering your real values. San Diego, Calif: University Associates, 1990

[14] E. Cech, The (mis)framing of social justice: Why ideologies of depoliticization and meritocracy hinder engineers' ability to think about social injustices. Engineering for Social Justice: Critical Explorations and Opportunities,10, 64-84, 2013

[15] S.D. Sheppard, A.L. Antonio, S.R. Brunhaver, and S.K. Gilmartin. "Studying the career pathways of engineers: An illustration with two data sets." In Cambridge handbook of engineering education research, pp. 283-310. Cambridge University Press, 2015
[16] M. Tremblay, T. Wils, and C. Proulx, “Determinants of career path preferences among Canadian engineers,” Journal of Engineering and Technology Management, vol. 19, no. 1, pp. 1–23, 2002.
[17] C. Rottmann, D. Reeve, S. Kovalchuk, M. Klassen, M. Maljkovic, and E. Moore, “Counting past Two: Engineers' leadership learning trajectories,” 2019 ASEE Annual Conference and Exposition Proceedings, 2019
[18] T.L. Adams, "Professions, hybrid professionalism and internal stratification: Evidence on Canadian engineers." Canadian Sociological Association, 2017
[19] M. Walker, Engineering identities. British Journal of Sociology of Education, 22(1), pp.75-89, 2001
[20] D. Chachra, D. Kilgore, H. Loshbaugh, J. McCain, and H. Chen, June. Being and becoming: Gender and identity formation of engineering students, American Society for Engineering Education Annual Conference and Exposition (pp. 13-250), 2008
[21] Brewer, M. B., & Gardner, W. (1996). Who is this “we”? Levels of collective identity and self-representations. Journal of Personality and Social Psychology, 71(1), 83–93.
[22] S. Stryker, Identity Salience and Role Performance: The Relevance of Symbolic Interaction Theory for Family Research. Journal of Marriage and Family, 30(4), 558– 564, 1968. https://doi.org/10.2307/349494
[23] H. Tajfel, Interindividual behaviour and intergroup behaviour. Differentiation between social groups: Studies in the social psychology of intergroup relations, 27-60, 1978
[24] H. Tajfel, J.C. Turner, W.G. Austin, and S. Worchel, S. (1979). An integrative theory of intergroup conflict.Organizational identity, 56(65), 1979, doi: 9780203505984-16.
[25] Baumeister, R. F. (1998). The self. In G. L. Gardner (Ed.), The handbook of social psychology, Vol. 1 (4th ed., pp. 680–726). New York, NY: McGraw-Hill.
[26] Engineers Canada, 2023 National Membership Information, Engineers Canada. Available at: https://engineerscanada.ca/reports/national-membership-report/2023-national-membership-information
[27] Denzin, N.K., The interpretive process, in The Qualitative Researcher's Companion, A.M. Huberman and M.B. Miles, Editors. 2002, Sage: Thousand Oaks. p. 349-366.
[28] Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis: An expanded sourcebook. Sage.
[29] B. Glaser, The constant comparative method of qualitative analysis. Social Problems, 12(4): p. 436-445, 1965
[30] A. Chan, C. Rottmann, E. Moore, D. Reeve, M. Maljkovic, and D. Radebe, "Engineering Leaders Retain Their Technical Identities: Living the sociotechnical Duality " in Canadian Engineering Education Association Annual Conference, Charlottetown, PEI, 2021.

[31] “The Washington Accord,” Engineers Canada, https://engineerscanada.ca/accreditation/the-washington-accord
[32] A. Chan, C. Rottmann, E. Moore, and D. Radebe, "Who identifies as an engineering leader? Exploring influences of gender, race, and professional experience," in American Society for Engineering Education Annual Conference and Exposition, Minneapolis, MN, 2022.
[33] Radebe, D., Rottmann, C., Chan, A., Macdonald-Roach, E., & Moore, E. (2023). A question of belonging in the engineering profession, Canadian Engineering Education Association Annual Conference, Kelowna, BC.
[34] A.H. Eagly, and S.J. Karau, Role congruity theory of prejudice toward female leaders. Psychological Review, 2002. 109(3): p. 573-598.