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Who identifies as an engineering leader? Exploring influences of gender, race, and professional experience

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Who identifies as an engineering leader? Exploring influences of gender, race, and professional experience

Abstract
This study explored the ways engineering leadership identity among engineering graduates differed by personal, social, and professional characteristics and experiences. We conducted analysis of variances and multiple regression modelling with data collected through an online survey with 1,240 participants from Ontario, Canada. Our analysis found engineering leadership identity to be positively associated with both engineering identity and technicist identity, suggesting that identifying with engineering leadership does not require engineers to surrender their technicist engineering identity. Our study also found women and younger engineering graduates on average measured lower on engineering leadership identity compared to men and older graduates, respectively. However, in circumstances where perseverance may be required, members of underrepresented groups were found to have stronger engineering leadership identity compared to others, contrary to our initial expectations. These findings further underscored the likely important relationship between identity and persistence, especially for underrepresented groups. The study's methodological limitations as well as implications for engineering leadership education, including the need to advance equity in 'identity workspaces', are explored.

Introduction

The importance of engineering identity has been variously explored within engineering education research. The literature has examined the influence of identity on student retention [1], [2], interrogated the gendered nature of engineering identity formation [3], [4], and conceptualized leadership identity development within engineering education [5]. In recent years, we have seen increasing attention on the need to incorporate leadership development as part of engineering education and to recognize engineering as a leadership profession [6]–[8]. Accordingly, engineering leadership identity, for its assumed relationship with the practice and development of leadership, has been a recent focus within engineering education research [9]–[11].

Through this study, we contribute to the literature that underscores the importance of engineering leadership identity. Furthermore, we present quantitative findings that suggested, *for members of underrepresented groups, a strong engineering leadership identity is important for persisting in engineering and leadership*. With a large-scale dataset (*N*=1,240) of mainly engineering graduates from Ontario, Canada, this study examined the relationship between engineering leadership identity and (1) other occupational/leadership identities, and (2) professional characteristics such as management role and licensure. As well, we are theoretically driven to explore the ways in which engineering leadership identity may be affected by social location (e.g., race, gender, age, and location of training) and experiences of discrimination.

To help delineate our analyses and select variables for inclusion in our quantitative modeling, we looked to two main theorical works: Faulkner's study on "gender-troubled engineering identities"[4]. This research explored the "symbolic gendering" of the many ideological dualities within the profession (e.g., technical/social; concrete/abstract) that serve to marginalize identities at odds with hegemonic masculinity. Faulkner pointed to the narrow 'technicist' identity most prominently associated with engineering that belies the true *socio*technical nature of all engineering work, interpreting this exclusion of the social as acutely gendered. We underscore leadership dimensions of engineering work as part of the excluded *social*.

Furthermore, we integrated Ibarra et al.'s conceptual work, which employed different theoretical lenses to examine the way role occupation, social categorization, and social interactions construct and reinforce leadership identity [12]. Ibarra et al. raised concerns over the challenges faced by "non-prototypical" leaders (i.e., leaders from underrepresented groups) whose leadership identity may be persistently challenged by others who see them as violating social/cultural norms.

Using a variety of quantitative analyses including multiple linear regression modeling [13], we explored the following research questions:

> **(r1)** *How does engineering leadership identity differ by social location and experiences of discrimination?*
> **(r2)** *How is engineering leadership identity related to licensure, management role, and other professional/leadership identities?*
> **(r3)** *How do relationships between professional characteristics/experiences and engineering leadership identity vary by social location and experiences of discrimination?*

We end by presenting the implications of our findings for engineering education and the profession of engineering at large, with acknowledgment of the limitations of this study that should be addressed through future research.

Engineering (leadership) identity and engineering education

As Tonso put it succinctly: "…for engineering identity, engineering education matters… [14]." From Situated Learning Theory (Lave & Wenger), we understand the educational context within which learners practice, develop skills, and interact with others are how identities are formed --- "learning, ….is the identity-making life projects of participants in communities of practice"[15]. Researchers concerned with engineering student retention have explored the ways in which identities can influence students' decision to pursue and persist in engineering. Comparing the experiences of those who persisted and those who switched out of engineering after first year, Pierrakos et al. found that only those who remained had some identification with the profession, and that the "persisters" overall had more meaningful experiences and exposure to engineering as a profession [1]. Examining how math and physics identities contributed to the decision to enter first year engineering, Godwin et al. found that the identity constructs based on interests, competence, and recognition, along with critical agency beliefs in advancing positive change in the world were positively associated with pursuing first year engineering at university. They also found that compared to men, math and physics identities were less predictive and critical agency beliefs more predictive of the choice to enter engineering for women [2].

The increasing focus of leadership as an area within engineering education has also led to interests in engineering *leadership* identity [5]. Using hierarchical linear modeling, Schell et al.

found engineering identity and student leadership experiences, among other factors, to be significant predictors of engineering students' leadership construct based on leadership self-efficacy and experience. This construct was chosen as the outcome variable for its assumed association with engineering leadership identity [9]. This study did not find gender or race to be associated with students' engineering leadership construct. Quantitative results overall have been inconsistent on the effects of gender on engineering identity. While there has been evidence that women engineering students are less likely to self-identify as an engineer [16], other findings have suggested there is no difference between women and men in engineering identity or persistence in engineering study [17], [18].

Effects of social location on engineering (leadership) identity

Qualitative studies have more consistently presented a nuanced picture of how gender and race can inform engineering (leadership) identity within both academic and workplace settings. Examining student engineering identities at a US university through ethnography, Tonso drew attention to the way one woman remained an invisible engineer in her community despite demonstrated competency and versatility. Because this student's performance of her 'engineer self' did not align with the few culturally produced or accepted engineering identities reserved for women on campus (most were uncomplimentary), she was 'othered' and remained unrecognized. Indications were that this student will likely leave engineering post graduation [19].

In another study, Du found women at a Danish university had to negotiate their gender identity in ways men did not (e.g., examples of women ensuring they were dressed non-provocatively, "becom[ing] deaf to the male jokes and language"), in order to be taken seriously within the masculine culture of their engineering program. The interpersonal and communication skills, strengths among the women in the study, did not align with the "technology-related identification" of engineering despite such competencies being essential to the practice of engineering broadly. The women's contribution on this front went unacknowledged by male colleagues and faculty and remained largely invisible [3].

These gendered identity negotiations were often carried into the workplace, where sexist interactions, gendered assumptions, and outright misogyny (e.g., "you are going to have to work with him but he hates women and doesn't want to work with women engineers'..") served to devalue, marginalize and undermine women's technical self-efficacy and engender ambivalent feelings towards their professional identity [20]. Even for seasoned engineering leaders across a variety of industry sectors, research suggests that gender and race can influence both the practice and identity of engineering leadership; gendered assumptions can limit the ways in which women can practice leadership, and any deviation from professional cultural norms (perhaps more so for underrepresented groups) can lead to others challenging an engineer's identity and sense of belonging to the profession [10].

Conceptual Framework

Engineering's Sociotechnical Duality

We drew from two main theoretical works to help us conceptualize the relationship between identities and underrepresentation in engineering and leadership. First, we looked to Faulkner's ethnographic work, which characterized two themes on the identities associated with engineering. One was the 'technicist' identity that is privileged within engineering culture and readily signifies traditional masculinities (e.g., 'practical' technology, hands-on tinkering, problem-solving rationality). The other was a 'heterogenous' identity that contains not only the technical identity but also other dimensions of the self (e.g., collaborator, communicator, team-builder) [4]. As Faulkner explained, these aspects of the self are traditionally assigned as feminine because of their social/relational nature. But while they are central to all engineering work (as all engineering work is sociotechnical), they sit in tension against the masculine ideologies of engineering and the dominant narrative of what engineering ought to be about [4].

Faulkner considered this division between the social and technical work within engineering, and the privileging of the technical over the social, as deeply gendered. Those who do not conform to the image of an archetypal engineer (rooted in notions of traditional masculinities) must do additional identity labour to prove to themselves and to others their belonging in the profession [4]. This may explain, as demonstrated in research findings including Faulkner's own, why engineers sometimes feel ambivalent and even resist management/leadership identities (i.e., social/relational work) as they perceived it to be "antithesis to" [21] or a "move away from engineering" [4]. In context of the larger movement to incorporate leadership learning into engineering education, the way leadership work is perceived to be a threat to engineering identity and professional membership can pose as a serious barrier for educators to promote leadership (identity) development among engineering students. From this *we expected engineering identity and technical identity to be inversely associated with engineering leadership identity, which we explored under* **(r2)**.

But formal management and leadership roles, like engineering, are also overrepresented by white men, more so the higher up the corporate ladder we go. In Canada as in the US, persistent underrepresentation of women and racialized people on corporate boards and in executive positions are well documented [22]–[24]. As Faulkner explained, while moving into formal management and leadership may feel like a "move away from engineering" for engineers of all genders, the move towards management and leadership is still more "gender authentic" for men in the way these positions are conferred authority and power [4] and are consistent with the privilege men are conferred under patriarchy, in the corporate world and more broadly [4], [25], [26]. In this way, the relationship between engineering and management/leadership is different for men than for other people of other genders, who are more likely to be perceived as inauthentic in both engineering and leadership. Based on this line of theory, in conjunction with our literature review findings, *we expected women and other underrepresented groups to measure lower on engineering leadership identity, as theoretically they are more likely to be on the receiving end of cultural messages of inauthenticity* **(r1)**.

Identity work in leadership

To further conceptualize the potential implications of a disparity in engineering leadership identity among engineers in different social locations, we looked to Ibarra et al.'s work that explores the relationship between leadership identity and development, drawing from role identity, social identity, and social construction theories [12].

According to role identity theory, social roles come with social expectations, and the commitment and practice to meet such expectations, by those assuming the roles, inform the extent to which the roles become integrated into their identity. Social identity theory underscores the importance of a shared collective identity among social group members and the tendency to valorize group members who exemplify the "prototypical characteristics". Lastly, social constructionism presupposes that identities are formed, maintained, and challenged through social/relational processes. Affirmation from others can serve to strengthen an identity, which in turn drives the motivation to pursue other opportunities that could further validate that identity. As such, leadership development is in part identity work (See Ibarra et al. for full references in their detailed summary [12]).

Employing the three theories to interpret leadership identity development, Ibarra et al. were able to clearly conceptualize the reasons underrepresented groups are likely to encounter barriers to leadership development and holding leadership positions[12]. As explained, in contrast to leaders who best represent "the prototypical characteristics of the group" required to facilitate buy-in and support from others, and who can readily conform to role expectations defined by cultural norms, leaders who do not conform for reasons related to race, gender, dis/ability, etc. face a particular set of challenges. When others perceive (consciously or unconsciously) a person's leadership to be in violation of expected social/cultural norms, it becomes difficult to foster the affirming social interactions and feedback from others required for the leadership identity development work. Without that affirming feedback (and in combination with experiences of harassment and discrimination), leaders may not fully internalize their leadership role and become less inclined to seek out greater opportunities to advance their leadership or further their leadership development. This perpetuates the cycle of underrepresentation in leadership despite efforts to increase representation by numbers (without broader cultural shifts) [12]. Our assumption, which we explore through **(r3)** is that *underrepresented groups in formal management/ leadership roles will measure lower in engineering leadership identity as compared to others in formal management/leadership roles*.

Methods

Data Collection

An online survey was conducted in winter 2021 in partnership between the Troost Institute for Leadership Education in Engineering (University of Toronto) and the Ontario Society for Professional Engineers (OSPE), a voluntary member-based organization that advocates on behalf of the engineering community. The questionnaire was developed collaboratively between both partners and comprised of questions on engineering graduates' professional background, demographic information, professional and leadership identity, perceptions of engineering leadership, and barriers to leadership. The instrument was piloted with a small group of our leadership program alumni (N=22) who were Engineers-In-Training (EITs) and licensed professional engineers having recently transitioned from graduate school to the workplace. Based on their feedback including comments on language clarity and survey length, we revised the questionnaire and formally launched the survey at the end of January 2021. The survey remained open for 4 weeks.

The email invitation to the survey was disseminated through OSPE's mailing list of members and associates. In total, we collected 1,240 responses that were included in the final dataset. From the number of email invitations that were opened, which we tracked via the online survey platform, we had a formal response rate of 9%. While proportion-wise the response rate is low, in absolute numbers 1,240 responses give us a considerably large dataset to conduct the quantitative analyses in this study.

Data Analysis
As part of the initial exploration of our data and to address (r1), we conducted independent samples t-tests and factorial analyses of variance. To address r2 and r3 we conducted ordinary least square (OLS) regression analysis, which allowed us to examine the relationship between individual predictors while controlling for the influence of other variables of interest.

For all three questions, our dependent variable is Engineering Leadership Identity, which is a composite scale that combines two items from the survey: "I think of myself as an engineering leader," and "Others think of me as an engineering leader." Each item was measured using a 5-point Likert scale (from 1 – *strongly disagree* to 5 – *strongly agree*). The scale was created by averaging the scores on both items, which together demonstrated strong reliability (Cronbach's $\alpha = .862$; Spearman-Brown Coefficient = .862)[1]

Other measures of identity were examined as predictors of Engineering Leadership Identity. Technicist Identity, Engineering Identity, and overall Leadership Identity were measured by the three respective items, 'My professional identity depends on my technical competence", "My Engineering Identity is central to who I am" and "My Leadership Identity is central to who I am", using the same 5-point Likert scale as noted above.

Occupational roles such as holding a formal management position and being licensed as a Professional Engineer (PEng) in Canada were included in the analysis as dummy variables (0,1).

Gender (women; men), race (BIPOC – Black, Indigenous, and People of Color; non-BIPOC), and location of undergraduate training in Engineering (in Canada; outside of Canada) were also examined as dummy variables (0,1). Although we collected information on gender in a nonbinary way, there were far too few responses indicated outside cis-women and cis-men (<5) that would allow for inclusion as their own separation categories. Although not ideal, we included self-identified trans-gender women in the women category, and trans-gender men in the men category. While we also collected more nuanced information on racial identities, at this early stage of our overall study we introduced race as a binary predictor.

Lastly, discrimination in leadership was measured through responses to the open-ended question: "Please list up to 3 BARRIERS you have encountered to your leadership (Point-form)." The

[1] The Spearman-Brown Coefficient is recommended for reporting the internal reliability of two-item scales, as opposed to Cronbach's Alpha [27]. We report both for comparison as readers may be more familiar with the reporting of Cronbach's Alpha.

qualitative data were coded in a way where any explicit mentions of sexism, racism, ageism, harassment, etc., were coded 1 for discrimination as a dummy variable. Again, there are more nuanced ways of coding and quantifying responses for this question, but we choose to code responses as a dummy variable at this stage of our data exploration.

Table 1.

Sample Description

Demographic & Professional Characteristics	% of *N*	*M* (*SD*)
Women	18.5	
BIPOC	18.7	
Internationally educated	24.6	
In formal management positions	45.2	
Licensed as Professional Engineers (P.Eng.)	79.6	
Experience discrimination as leadership barrier	11.3	
Age		51 (16)
Scores (1 to 5) on Identity Measures		
Engineering Leadership Identity		3.76 (.93)
Technicist Identity		4.52 (.73)
Engineering Identity		3.92 (.94)
General Leadership Identity		3.93 (.95)

Results

We began by addressing our first research question:

(r1) *How does engineering leadership identity differ along lines of race, gender, location of training, experiences of discrimination, and at their sections?*

As a way of exploring our data before conducting our multiple regression modeling, we conducted means-comparison analyses to examine how engineering leadership identity differed by demographic characteristics known to be associated with inequity and exclusion within engineering and engineering education (i.e., race, gender, international training), along with experiences of discrimination as a barrier to leadership. We included age as a variable as well, as many responses to the open-ended question on barrier to leadership mentioned age as a basis of discrimination by both younger and older respondents.

Independent samples t-tests found significant differences in engineering leadership identity based on gender, location of training, and age (Table 2). On average, men and older respondents had a stronger engineering leadership identity (3.83 and 3.95) compared to women and younger respondents (3.49 and 3.57), respectively. International engineering graduates also had a stronger engineering leadership identity (4.00) compared to Canadian trained graduates (3.68). Keep in mind that our sample only included international graduates who were still connected to or held an interest in professional engineering, even though they may not be licensed to practice in Canada. International engineering graduates who have left the field entirely with zero lingering attachment or interest in engineering would not be part of our sample. One interpretation of the stronger engineering leadership identity in this group is that a strong identity is associated with being able to overcome licensure barriers or served as motivation to remain attached to the field even without licensure – we elaborate on this theory and the implications to any sampling biases in our limitations section.

Table 2.

T-tests results comparing engineering leadership identity by social location and experience of discrimination

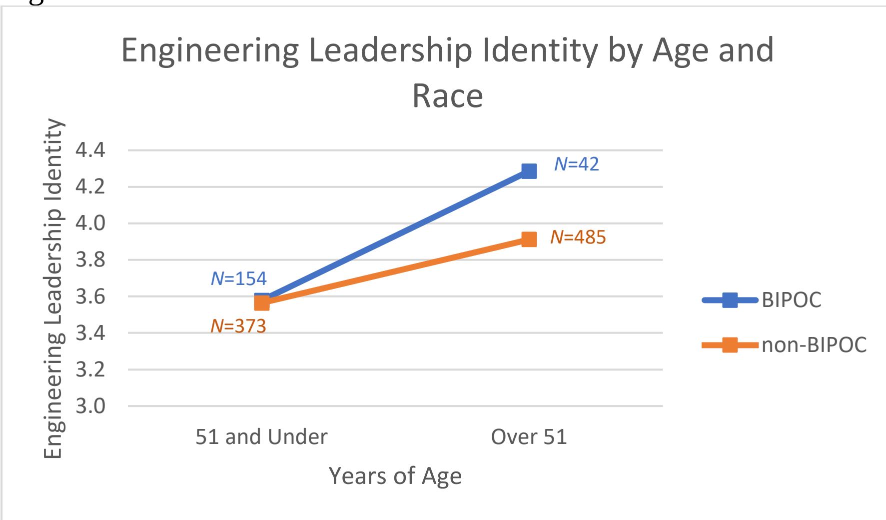
		M(SD)	Mean difference	t	Cohen's *D*
Race	BIPOC	3.71(.95)	.06	0.81	
	Non-BIPOC	3.77(.94)			
Gender	Women	3.49(.90)	.34	4.59***	.365
	Men	3.83(1.02)			
Location of Training	In Canada	3.68(.94)	.31	5.27***	.340
	Outside Canada	4.00(.86)			
Discrimination as Leadership Barrier	Yes	3.81(.93)	.06	0.70	
	No	3.75(.93)			
Age	≤ 51	3.57(.86)	.37	6.95***	.410
	> 51	3.95(.86)			

***$p<.001$

Because we were also interested in whether engineering leadership identity differed by demographic variables in intersectional ways, we conducted factorial analyses of variance with all possible pair-wise variations of the predictor variables (e.g., gender x race; gender x location of training; race x age; age x location of training). For each test, a significant interaction between the two predictors would suggest that engineering leadership identity differed intersectionally between groups. For example, a significant interaction between gender and race would suggest a significant difference in engineering leadership identity somewhere among the groups: BIPOC women, BIPOC men, non-BIPOC women, and non-BIPOC men.

In our analysis, we found only one significant interaction effect among all possible pair-wise combinations, between Age and BIPOC. BIPOC engineering graduates who were older had significantly higher engineering leadership identity [Mean (SD) = 4.29 (.63)] compared to others (See Figure 1.). We interrogate the meaning of this finding further in the Discussion section.

Figure 1.



Next, we conducted Ordinary Least Square regression to estimate the association between engineering leadership identity and variables related to professional experience and identities, to explore research question 2:

(r2) *How is engineering leadership identity related to licensure, management role, and other professional/leadership identities?*

In Model 1, results show that engineering graduates' technical identity, engineering identity, and leadership identity were all positively associated with engineering leadership identity. Perhaps contrary to theory [4] but consistent with empirical findings [10], having a strong technical identity did not detract from having a strong engineering leadership identity. Given engineering identity was also a significant predictor while controlling for technical professional identity, this suggests that there was more to engineering identity than the 'technicist' aspect that contributed to a person's engineering leadership identity. Of all three predictors, general leadership identity was the strongest predictor – suggesting that engineers with a strong general leadership identity also have a strong *engineering* leadership identity. An increase of 1 in general leadership identity is associated with an increase of .39 in engineering leadership identity.

Table 3.
Summary of regression models of Engineering Leadership Identity

	β (SE)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	.47(.17)**	.36(.17)*	.12(.20)	.07(.22)	1.02(.59)	.13(.20)
Technicist ID	.23(.03)***	.22(.03)***	.23(.04)***	.27(.04)***	.07(.11)	.25(.04)***
Engineering ID	.18(.03)***	.18(.03)***	.15(.03)***	.12(.03)***	.22(.09)*	.15(.03)***
General Leadership ID	.39(.03)***	.37(.03)***	.38(.03)***	.40(.03)***	.26(.09)**	.37(.03)***
Management		.20(.05)***	.18(.05)***	.8(.06)	.44(.18)*	.10(.06)
PEng		.19(.06)**	.08(.07)	.07(.07)	.08(.07)	.07(.07)
Age			.01(.002)***	.01(.002)***	-.01(.01)	.01(.002)***
Women			-.14(.07)*	-.09(.43)	-.14(07)*	-.31(.08)***
BIPOC			.02(.07)	.03(.06)	.03(.07)	.02(.07)
International engineering graduates			.10(.60)	.10(.08)	.09(.06)	.10(.06)
Discrimination			.02(.08)	.01(.08)	.03(08)	.02(.08)
Tech ID x Women				-.09(.08)		
Eng ID x Women				.11(.07)		
GenLdr ID x Women				-.07(.07)		
Mge x Women				.41(.13)**		.41(.12)***
Tech ID x Age					.003(.002)	
Eng ID x Age					-.001(.002)	
GenLdr ID x Age					.003(.002)	
Mge x Age					-.01(.003)	
R^2	.301	.325	.357	.366	.361	.364
df	5, 1151	5, 1151	10, 967	14, 963	14, 963	11, 966
F	172.67***	110.88***	53.64***	39.765***	38.850***	50.263***

*p<.05; **p<.01; ***p<.001

In Model 2, we added two more variables, formal management role and being licensed as a professional engineer, as predictors of engineering leadership identity. Results showed that both management role and licensure are positively associated with engineering leadership identity. Those who were licensed and in management on average have a higher engineering leadership identity (by .20 and .19, respectively) compared to others who were not, controlling for other predictors in the model.

Lastly, we re-introduced the variables of race, gender, age, location of training, and discrimination to explore our final research question:

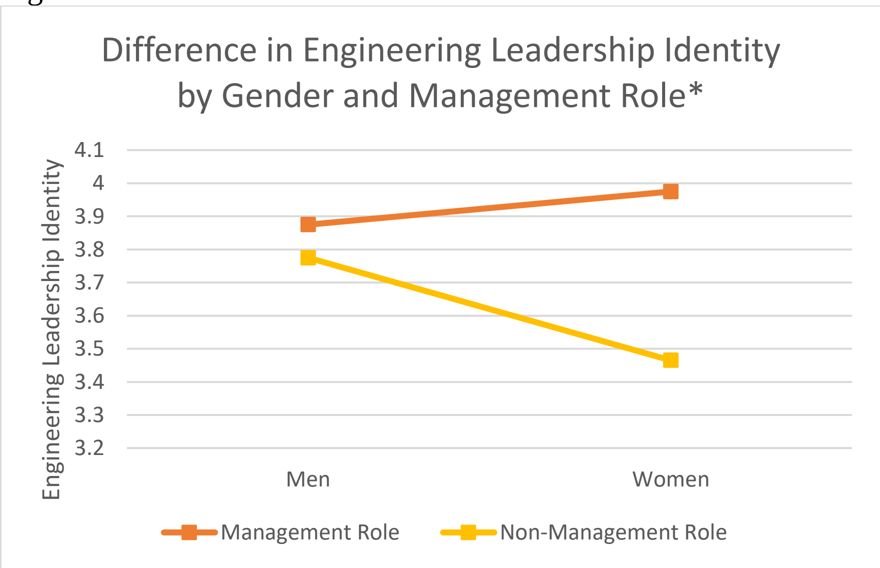
(r3) *How do relationships between engineering leadership identity and its predictors vary by gender, race, location of training, and experiences of discrimination?*

We began by looking at the main effect of this next set of variables, controlling for the variables previously entered in model 2. Consistent with our t-tests results, age and gender were significantly associated with the outcome variable (Model 3). For every increase of 10 years in age we see an associated increase of .10 in engineering leadership identity, controlling for other predictors. Women on average have a lower engineering leadership identity by .14 compared to men, controlling for other predictors. The difference in engineering leadership identity we saw between Canadian and international engineering graduates from the t-tests were no longer statistically significant once we controlled for other variables in the regression model. Licensure was also no longer significantly associated with engineering leadership identity once we controlled for other predictors in Model 3.

Having considered the main effects of the demographic/equity-associated predictors, we explored whether these same predictors interacted with professional identities/experiences to influence engineering leadership identity. Only significant main effect predictors from previous models were tested for interaction effects. In Model 4, we see that gender significantly interacted with management. In Model 5, we see that age did not interact significantly with any of the professional identities/experience variables. For a more parsimonious final model, we removed all non-significant interaction terms (Model 6).

In our final model, we see that technicist, engineering, and general leadership identities were all positively associated with engineering leadership identity, controlling for all other predictors. Of note, licensure and management (as main effects) were no longer significant predictors once we controlled for other predictors in the model. We do see a strong interaction effect with gender and management as predictor of engineering leadership identity. For women in non-management roles, the model estimated a weaker average engineering leadership identity (-.31) compared to men in non-management roles. However, for those in management, it appears that being a woman was associated with a *higher* engineering leadership identity (.10 = .41 +(-.31)) compared to being a man (See Figure 2.). Our results suggest that holding a formal management position does not appear to be significantly associated with engineering leadership identity, *unless you are a woman*. Implications are discussed below.

Figure 2.



*For engineering graduates with average technical, engineering, and general leadership identities, who are 40 years of age, non-BIPOC, and Canadian trained.

Discussion

Identity and persistence for underrepresented groups

Many of our findings were consistent with theory-informed expectations. However, we also uncovered surprising findings. While at first blush these surprises countered expectations, when unpacked further we found that they aligned with our theoretical assumptions.

As expected, on average women and younger engineering graduates measured lower in engineering leadership identity compared with men and older engineering graduates, respectively. Without accounting for any other factors, international graduates had higher engineering leadership identity compared to Canadian graduates. Our sample of international engineering graduates only included people affiliated with OSPE. As such, these were internationally trained graduates who had become licensed engineers or otherwise continued to identify with engineering despite not being licensed to practice. Given the well documented structural barriers for international engineering graduates to become licensed in Canada [28], [29], and the theory that identity can serve as an internal compass for navigating career paths, it stands to reason that those who likely encountered barriers and remained committed to engineering would have a stronger identity, compared even with the average Canadian engineering graduate.

A similar interpretation could apply to some of our other findings, where members of underrepresented groups appeared to have stronger engineering leadership identity in contexts where perseverance was required. The first is where older BIPOC engineering graduates were found to have higher engineering leadership identity compared to others, suggesting BIPOC engineering graduates who persisted to later stages of their careers (i.e., those who did not exit engineering) were the ones with the strongest engineering leadership identity. The second finding occurred where, despite women on average having weaker engineering leadership identity, *women in management* were found to have the highest engineering leadership identity compared to everyone else (i.e., men in both management and non- management and other women in non-management roles). Women in non-management roles had the lowest engineering leadership identity, substantively lower than everyone else including men also outside of management, controlling for other factors. The larger gap in engineering leadership identity between women in and out of management roles suggests that the strength of identity associated with reaching management is greater for women then men. Put another way, we interpret the findings to suggest that women have to expend more labour doing identity work to reach management roles compared to men, an explanation in line with arguments put forward by Faulkner and Ibarra et al. [4], [12]. Our initial hypotheses that members of underrepresented groups would measure lower in engineering leadership identity did not allow for the possibility that those with more precarious identities may have left engineering behind. Compounding this issue, our sampling strategy constrained our ability to reach engineering graduates who work in non-traditional industry sectors. Notwithstanding, our findings do suggest a disparity in engineering leadership identity along lines of race, gender, and licensure, but demonstrated in unexpected ways.

Finally, the last unexpected finding that countered our theoretical assumption was that both technicist and engineering identities were positively associated with engineering leadership identity. From Faulkner's account of engineering's social-technical divide, we expected those with the strongest technical identity would have the weakest engineering leadership identity (i.e., an inverse relationship). We found the opposite to be true in our data. The finding that engineering graduates can retain strong technicist and engineering identities while *also having a strong engineering leadership identity* suggest that engineering students do not have to resist leadership for fear of losing their engineer self. This may be an important message for engineering educators to get across to engineering students who are sceptical of leadership in order to facilitate and support their leadership identity and development work.

Implications for engineering education

There were a number of implications from our study for engineering education and engineering more broadly. As mentioned above, our findings suggest there are not necessarily trade-offs between an engineering identity and leadership identity; an engineering leader can strongly identify as being an engineer *and* a leader. If educators are ever to persuade the unconvinced that leadership work is part of all engineering work, this is particularly important to get across to students who may see leadership as the antithesis to what they hold dear about engineering,

Another implication was that general leadership identity appeared to be strongly associated with *engineering* leadership identity. For engineering education, the continued promotion of leadership work outside of an engineering context (e.g., community-based service learning) can be a good parallel to the curriculum-based effort to promote engineering leadership identity and leadership development.

Alongside the call to centre equity and inclusion within engineering education [30], [31], this study highlighted the need to centre equity and inclusion within engineering leadership education as well. Who gets to lead? Who identifies with leadership? There are important points of discussions to have as part of leadership education, if the goal is to have future engineering leaders be part of the movement to advance equity and inclusion in engineering and beyond.

Referring to the importance of creating environments that are conducive to leadership identity development, Ibarra et al. [12] drew heavily from Petriglieri et al.'s concept of identity workspaces as 'holding environments' for identity work [32]. According to Petriglieri et al., there are three essential and overlapping elements needed to facilitate effective identity work: (1) reliable social defenses to protect against threats or disturbances; (2) sentient communities that foster a sense of belonging that is both lived and aspirational; and (3) vital rites of passage that allow members to enact the "mythology" and embody the values of the group they are entering [32].

There are many aspects of engineering leadership education that map onto the three elements: the strong emphasis on communication and relational skill-building that can serve as social defenses; the large number of clubs, groups, and teams that can facilitate the sociodynamics necessary to foster a sense of belonging; and the many vital rites of passage such as participating in engineering competitions and the 'passing of the torch' by senior to more junior team/club members as they rise among the ranks. While these leadership identity workspaces exist as part of engineering education, they may not be utilized equally or engaged as such by all engineering students. As a reminder, Ibarra et al. noted the "difference between identity workspaces used only for cultural replication versus those that enable cultural reflection and change," with the latter being what is necessarily to bring about true diversity and inclusion [12]. Building on the exiting identity workspaces within engineering leadership education, the next step is to ensure theses spaces, and the *ideas of leadership* in which they hold, are accessible and equitable for all engineering students.

Limitations & future research

One of the biggest limitations of this study is that we were only able to reach engineering graduates who at minimum were tangentially affiliated or identified with engineering in some way. The voices of engineering graduates who had exited engineering completely, by choice or otherwise, were not included in our study. Any study interested in examining the influence of inequity and exclusion on engineering (leadership) identity should include those who potentially have been the most excluded, and future studies must account for this gap when considering sampling options. One strategy may be to partner with university alumni offices in order to reach out to all engineering graduates, especially those who have not remained in engineering or pursued professional licensure.

Another limitation was that we were unable to consider many of the social identities and experiences of discrimination in a more nuanced way, once we decided to examine these factors as binary variables. While the quantitative analyses produced noteworthy patterns regarding the broader picture, qualitative data can help to supplement our interpretations of the patterns that emerged, which will be part of the focus of the next stage of our study.

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