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Can She Relate? Examining Undergraduate Women's Experiences with Engineering Peers

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Can She Relate? Examining Undergraduate Women's Experiences with Engineering Peers (Research, Full)

Abstract

Although women's under-representation in engineering has been well-documented, it remains a pressing issue. As such, it is necessary to examine factors that contribute to persistence in engineering among the few women that do enter this highly male-dominated field. The chilly climate in STEM fields is often cited as a source of women's attrition from engineering. At the same time, gender scholars have posited that gender identities can vary among individuals, which in turn, can shape their lived experiences.

Given the masculine culture of engineering, undergraduate women who view their gender identity as more typically feminine may relate less to their engineering peers. Thus, the purpose of this full research paper is to examine the relationship between gender typicality and undergraduate women's feelings of being included by their engineering classmates. This paper will explore the following research questions: (1) *What is the relationship between gender typicality and women's feelings of being included by female engineering peers?* (2) *What is the relationship between gender typicality and women's feelings of being included by male engineering peers?* To address these questions, the paper will utilize quantitative survey data from a sample of approximately 420 undergraduate women of racially diverse backgrounds from across the U.S. who are studying engineering and participate in an engineering professional organization focused on supporting women in engineering and technology. Key findings include differences in feelings of being included by female and male peers. Importantly, contrasting patterns between women's gender typicality and feelings of being included by female and male engineering peers, respectively, were also observed.

Introduction

Over the last 20 years, women's under-representation in engineering remains relatively unchanged [1]. Thus, as they comprise the numerical minority in this highly male-dominated field, it is critical to examine possible factors that may lead to their persistence in engineering. Notably, perceived inclusion has been found to be related to women's persistence in STEM [2], [3]. In contrast, the chilly climate experienced by women in STEM leading to their departure is also well-documented [4], [5]. Yet, this body of literature often fails to consider the possible heterogeneity in how women studying engineering view their gender, and in turn, how this heterogeneity relates to how they perceive being included in engineering.

While this group of women share the common academic pursuit of an engineering degree, there may be variation in their views about their gender. Research on women's identity interference

and compatibility suggest that some women in STEM struggle with the dissonance of seeing themselves as STEM people while at the same time seeing themselves as a member of a minoritized group in engineering [6], [7]. Still, there is limited literature that has explored what particular aspects of women's gender identity lead to this identity interference. For instance, women who identify as being more stereotypically feminine, may have difficulty identifying with engineering.

Therefore, this quantitative research study attends to how gender typicality relates to feelings of inclusion among this group of undergraduate women in engineering. Specifically, this study utilizes survey data from a sample of over 400 racially diverse women in engineering from across the U.S. who participate in an engineering professional organization focused on supporting women in engineering and technology. As women in engineering, they may be viewed as unique for pursuing a non-gender normative field such as engineering. Thus, what I seek to understand is if their views of their gender are related to their perceptions of being included by their engineering peers. In doing so, I investigate the following research questions: (1) *What is the relationship between gender typicality and women's feelings of being included by female engineering peers?* (2) *What is the relationship between gender typicality and women's feelings of being included by male engineering peers?* Overall, this study makes a unique contribution to the field of engineering education by considering how young women's views of their gender relate to being included in engineering, which in turn, can contribute to their persistence in engineering.

Background

This study is rooted in theories that conceptualize gender as multi-dimensional [8]. This notion is important to consider as women pursuing engineering degrees may be perceived as atypical for their gender for doing so. However, although sharing a common gender non-normative interest in engineering, undergraduate women in engineering may still identify with aspects of femininity and masculinity [9], [10]. At the same time, we acknowledge that gender also operates as a social system, which can constrain or allow certain gender identities as permissible [11]. In particular, as engineering remains a typically masculine space, individual women may experience engineering spaces differently in relation to how much they perceive their gender identity as being similar to the people around them.

This study focuses on engineering women's perceived relatedness to STEM peers, which refers to an individual's perceived feelings of inclusion by STEM peers [3], [12]. This can also be characterized as a sense of belonging, as this construct describes how young women feel included in the environment shared with STEM peers [2], [3]. Importantly, in the context of engineering, a field that is predominantly men, women's gender identities can become salient and matter for how they relate to the people around them. Hence, engineering women may

perceive congruence or, on the contrary, incongruence between their gendered selves and the masculine world of engineering through their feelings of relatedness to their peers.

Previous scholars have utilized gender identity measures to predict young women's interest in male-dominated fields [13], [14]. However, gender identity constructs are rarely examined in relation to women's engineering outcomes. Therefore, I draw from literature on STEM identity interference and compatibility to describe how engineering women's perceptions of feminine typicality and masculine typicality, or perceptions of being similar to typical women and men, respectively, may shape their sense of relatedness to engineering classmates. For example, a few research studies show that women studying STEM perceived incompatibility between their gender identity and their STEM identity [6], [7], indicating that perhaps women who report more similarity with women may find it challenging belonging in STEM. Conversely, some qualitative studies examining gender identity negotiation found that young women who feel most similar to men, tend to perceive being included more by their STEM peers, particularly by the young men in STEM spaces, more so than young women who express feeling more similar to typical young women their age [9], [10]. Together, this body of literature points to how gender typicality may relate to women's perception of being included by the men and women in their engineering classes.

Data and Methods

The quantitative survey data utilized for this study come from a larger IRB-approved research project on young women's engineering experiences. Survey participants are undergraduate women who participate in an engineering professional organization that supports women in engineering and technology fields. As participants of this national organization, the young women can be members of the local group at their college or university. The research team for the larger research project recruited participants by emailing members of this national organization using their listserv. The engineering women in this study have self-selected to participate in this organization and are enrolled across multiple institutions of higher education.

For this study, I combined cross-sectional survey data from across two years, such that engineering women participants completed a survey in either Spring 2019 or Spring 2020. As the focus of this study is women in engineering, the final analytic sample is 420 undergraduate women in engineering from across the U.S. who self-identified as female. Further, the young women in this study self-reported their race/ethnicity, which included selection of any or multiple racial/ethnic identities, such as, American Indian or Alaska Native, Asian, Black, Latinx, Native Hawaiian or Pacific Islander, and/or White. A composite race/ethnicity variable was constructed to distinguish between Asian, Black, Latinx, multiracial, and White women. Multiracial women included those who had self-identified with two or more racial/ethnic

identities. As shown in Table 1, the final analytic sample includes 46 Asian, 9 Black, 34 Latinx, 29 multiracial, and 302 White women.

Author's positionality

The author of this study identifies as a Latinx–Asian cisgender woman who studied engineering for her undergraduate degree and is currently a tenure-track assistant professor in STEM education. She considers herself an emerging scholar whose work explores issues of equity in STEM education, with a specific focus on historically minoritized learners, such as young women and Students of Color. In engaging in this research work, she is aware that while her individual experiences, particularly as a past undergraduate engineering student, provide insight for interpreting the analytic results, these perspectives may be limited and can lead to oversights. Therefore, the author has carefully reflected and considered alternative interpretations of the results through discussions with equity-focused STEM education colleagues and scholars.

Measures

Dependent measures for this study capture engineering women's perceived feelings of relatedness to their engineering peers, including men and women classmates. As this study explores how perceived feelings of inclusion can be gendered, I include separate measures for *perceived feelings of relatedness to male* and *female engineering classmates*. Both dependent variables were measured using a previously validated scale variable [12]. *Perceived feelings of relatedness to male engineering classmates* is a three-item scale variable that measures the extent to which participants perceive feeling included by the men in their engineering classes. Similarly, *perceived feelings of relatedness to female engineering classmates* is also a three-item scale variable capturing participants' sense of being included by the women in their engineering classes. Response categories for the items in these scale variables ranged from 1 (strongly disagree) to 5 (strongly agree). Items for these scale variables include: "I can relate to the men (women) around me in my engineering classes," "I have a lot in common with the men (women) in my engineering classes," and "the men (women) in my engineering classes share my personal interests." For this study, Cronbach's alpha for *perceived feelings of relatedness to male engineering classmates* and *perceived feelings of relatedness to female engineering classmates* is 0.83 and 0.84, respectively, suggesting high internal scale consistency.

As this study aims to explore potential relationships between different dimensions of gender identity and the engineering outcomes described earlier, the key independent measures are variables that assess various aspects of gender typicality. This includes two gender typicality measures: *feminine typicality* and *masculine typicality*. These scale variables capture an individual's view of their gender identity as being similar to typical women and men their age, respectively. They have been previously validated [8], and results from confirmatory factor

analyses indicated that scale variables for *feminine typicality* (Cronbach's alpha=0.78) and *masculine typicality* (Cronbach's alpha=0.70) have good internal reliability. The scale variables for *feminine typicality* and *masculine typicality* were each constructed by averaging across four items (e.g., "I feel similar to women my age"), and response categories for these items ranged from 1 (strongly disagree) to 5 (strongly agree).

In Table 1, I also include other background and control variables, such as mother's highest level of education, year in college, grade point average (GPA), and cohort. Prior research has found that these factors may be related to students' identification with engineering [15], [16]. The engineering women were asked to report their *mother's highest level of education* as either: less than a high school diploma; high school diploma; associate's degree; bachelor's degree; master's degree; or PhD, MD, or law degree. As most participants reported having highly educated mothers, a dichotomous variable was created to differentiate between those whose mothers' highest level of education was at least a bachelor's degree (74.76%) and those whose mothers' highest level of education was less than a bachelor's degree (25.24%). Engineering women were asked to report their class standing. The original variable included 6 categories: 1st, 2nd, 3rd, 4th, 5th, and 6th and beyond. However, for ease of interpretation, the number of categories was reduced to two: upper level (those in at least their 3rd year) and lower level (those in their first two years). Overall, most indicated being in the final years of their undergraduate degree (60.24% are *upper level*). Similarly, the original variable for GPA included the following choices: less than 2.00, 2.00-2.49, 2.50-2.99, 3.00-3.49, and 3.50-4.00. Therefore, *high GPA*, differentiates between those who self-reported earning a *high GPA* (59.76%) of 3.50 and above and those with a GPA of less than 3.50. *Cohort* is a binary variable constructed by the research team to distinguish young women who completed the survey in Spring 2019 or in Spring 2020. These background characteristics of the sample are also summarized in Table 1.

Table 1. Sample characteristics

	Proportion or Mean (SD)
Dependent variables	
Perceived relatedness to female engineering classmates	3.60 (0.79)
Perceived relatedness to male engineering classmates	3.25 (0.79)
Key independent variables	
Feminine Typicality	3.57 (0.72)
Masculine Typicality	3.23 (0.66)
Background and control variables	
Race/Ethnicity	
Asian	10.95%
Black	2.14%
Latinx	8.10%

Multiracial	6.90%
White	71.90%
Mother's highest level of education	
Less than a bachelor's degree	25.24%
At least a bachelor's degree	74.76%
Year in college	
First or second year	39.76%
Third year or more (upper level)	60.24%
GPA	
Less than 3.50	40.24%
3.50 or above (high GPA)	59.76%
Cohort	
2019	47.14%
2020	52.86%
N	420

Analytic approach

To answer the research questions for this study, I conducted linear regression analyses to examine the relationship between different gender typicality measures and young women's perceived relatedness to the men and women in their engineering classes. These analyses begin with baseline models, which include all key independent measures (*feminine typicality* and *masculine typicality*) as predictors of *perceived relatedness to male engineering classmates* and *perceived relatedness to female engineering classmates*, respectively. Subsequent models include all background and control variables to explore whether any significant relationships between the gender typicality measures and perceived relatedness to engineering classmates remain even with the inclusion of these factors.

Results

Overall, the engineering women in this study report, on average, feeling some sense of relatedness to male engineering classmates (M=3.25, SD=0.79) and female engineering classmates (M=3.60, SD=0.79).Yet, they perceive significantly more inclusion from the women more so than from the men in their engineering classes ($t(419)=6.805$, $p<.001$), and the magnitude of this difference is moderately sized (Cohen's d=0.44). As mentioned earlier, this study explores how engineering women's immediate connection to engineering may be gendered by examining the relationship between gender typicality measures and perceived inclusion by

female and male engineering classmates, separately. Therefore, I present results from regression models predicting these dependent variables in the sections below.

RQ 1: Predicting relatedness to female engineering classmates

Table 2 shows the results of linear regression models predicting *perceived relatedness to female engineering classmates*. Beginning with the baseline model, Model 1, there is a positive and significant association between *feminine typicality*, or identifying with typical women their age, and *perceived relatedness to female engineering classmates*. Further, this model shows that *masculine typicality* is not associated with *perceived relatedness to female engineering classmates*.

Turning to Model 2, *feminine typicality* remains a positive and significant predictor of engineering women's feelings of inclusion by their female engineering classmates even with the inclusion of various background and control variables. In this full model with controls, *masculine typicality*, again, is not a significant predictor of *perceived relatedness to female engineering classmates*. In fact, there is no significant relationship between any of the background and control variables and engineering women's feelings of inclusion from female engineering classmates.

Table 2. Results of regression models predicting engineering women's relatedness to female engineering classmates

	Model 1 baseline model	Model 2 full model
Key independent variables		
Feminine typicality	0.470***	0.467***
	(0.051)	(0.052)
Masculine typicality	-0.031	-0.040
	(0.056)	(0.057)
Background and control variables		
Race/Ethnicity (ref: White)		
Asian		-0.001
		(0.114)
Latinx		-0.134
		(0.132)
Black		-0.229
		(0.245)
Multiracial		-0.212
		(0.140)
Mother's highest level of education is at least a bachelor's degree		-0.083
		(0.083)

2019 cohort		-0.100
		(0.073)
Upper level		0.069
		(0.073)
High GPA		0.105
		(0.074)
Constant	2.019***	2.198***
	(0.215)	(0.275)

Coefficients are from regression models, $N = 420$; robust standard errors are in parentheses
*** p<0.001, ** p<0.01, * p<0.05

RQ2: Predicting relatedness to male engineering classmates

Next, I describe the results from linear regression models predicting *perceived relatedness to male engineering classmates*, which are shown in Table 3. As indicated in Model 1, *masculine typicality*, or identifying with typical men their age, is positively and significantly related to engineering women's stronger feelings of *relatedness to men* in their engineering classes. In contrast, *feminine typicality* is negatively and significantly related to engineering women's lower levels of *perceived relatedness to male engineering classmates*.

As Model 2 shows, the effects of *feminine typicality* and *masculine typicality* remain significant and robust with the inclusion of background and control variables. Additionally, women with a *high GPA* have higher feelings of *relatedness to men* in their engineering classes than women without a high GPA. Women who completed the survey in Spring 2020 rather than in Spring 2019 reported significantly lower levels of *perceived relatedness to male engineering classmates.* Aside from these measures, no other control variables were significantly associated with engineering women's *perceived relatedness to men* in their engineering classes.

Table 3. Results of regression models predicting engineering women's relatedness to male engineering classmates

	Model 1 baseline model	Model 2 full model
Key independent variables		
Feminine typicality	-0.228***	-0.227***
	(0.046)	(0.045)
Masculine typicality	0.742***	0.719***
	(0.049)	(0.050)
Background and control variables		
Race/Ethnicity (ref: White)		
Asian		-0.144
		(0.099)
Latinx		0.068

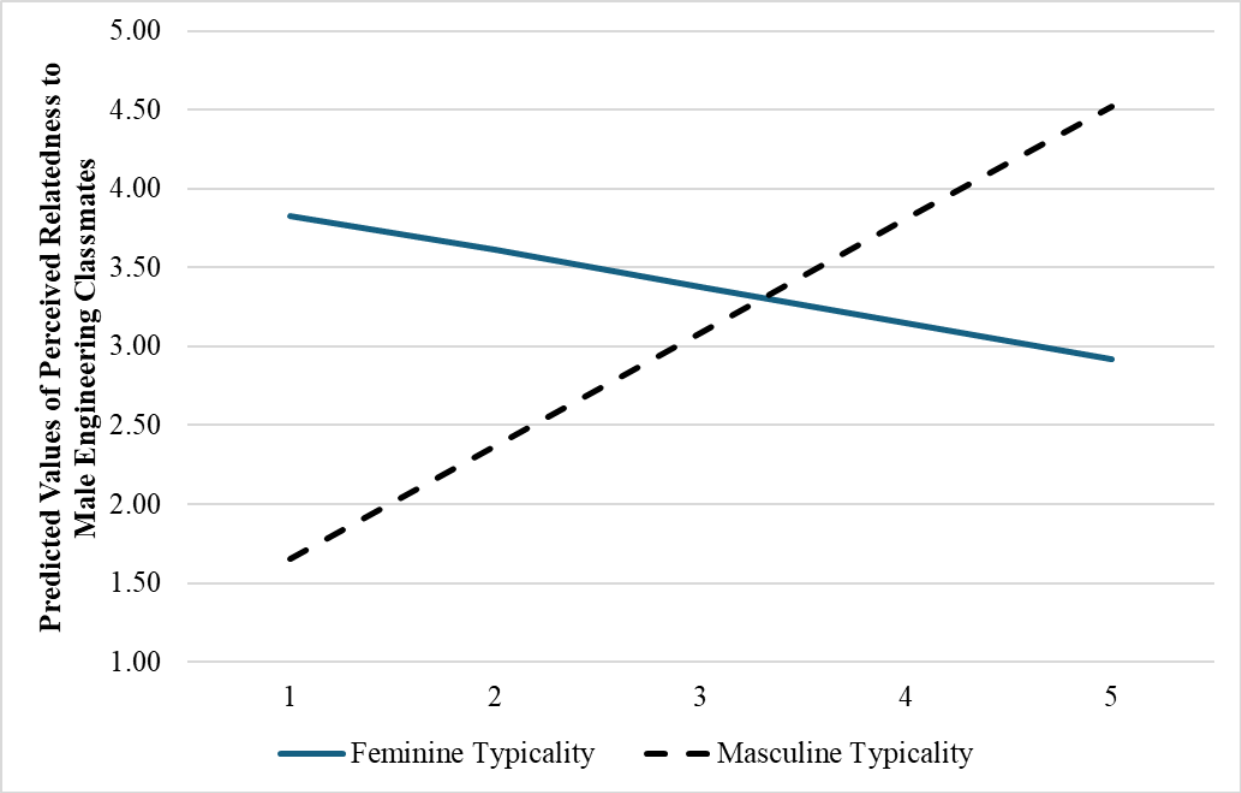
		(0.115)
Black		-0.062
		(0.214)
Multiracial		-0.013
		(0.123)
Mother's highest level of education is at least a bachelor's degree		-0.026
		(0.072)
2019 cohort		-0.196**
		(0.064)
Upper level		0.048
		(0.064)
High GPA		0.220***
		(0.064)
Constant	1.669***	1.717***
	(0.191)	(0.213)

Coefficients are from regression models, N = 420; robust standard errors are in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Additionally, since both *feminine typicality* and *masculine typicality* are significantly related to feeling included by male engineering classmates, I tested whether these coefficients from the full model (Model 2) were different in magnitude. A post hoc test confirmed that the coefficient for *masculine typicality* (0.719) is significantly larger in magnitude than the coefficient for *feminine typicality* (-0.227) ($\chi 2(1)=58.31$, p<.001). To illustrate, I show in Figure 1 the predicted values of *perceived relatedness to male engineering classmates* over specific values of *feminine typicality* and *masculine typicality* that range from 1 to 5, minimum and maximum values of these scale variables, respectively, while holding all other variables in the model to the mean.

Specifically, as *feminine typicality* increases over the aforementioned specified range of values, engineering women's *perceived relatedness to male engineering classmates* decreases by 0.91. In contrast, as *masculine typicality* increases over the same range of values, women's *perceived relatedness to male engineering classmates* increases by 2.87 (an increase of about three levels of agreement in a scale of five). Consequently, the negative effect of *feminine typicality* on women's perceived inclusion by male engineering classmates is modest compared to the positive effect of *masculine typicality*.

Figure 1. Main Effects of Feminine Typicality and Masculine Typicality on Perceived Relatedness to Male Engineering Classmates



Discussion and Conclusion

In this study, I examined how the measures of gender typicality of undergraduate women in engineering are associated with how they perceived being included by peers in engineering. Notably, the differentiation between feminine and masculine aspects of gender identity among this group of women is often overlooked in engineering education. Countering this oversight, I find that among this group of women studying engineering, different facets of gender typicality were predictive of their sense of connection or relatedness to engineering peers, as measured by their sense of relatedness to engineering classmates.

Specifically, expressing strong similarity with typical men their age predicts a higher sense of inclusion from male engineering classmates. Yet, highly identifying with typical women their age led to a clash in women's sense of relatability with men in their engineering classes. These related findings point to the privileged role of masculinity in engineering. This identification with masculinity affords engineering women an immediate connection to engineering, suggesting that indeed, engineering spaces are not perceived as gender neutral, value-free spaces by the relatively few women who participate in them [17], [18].

Moreover, this study also shows how specific aspects of masculinity are valued and positioned in a higher regard within engineering. For instance, a high GPA predicted higher feelings of relatedness to male engineering classmates. Perhaps, this is unsurprising given that a high GPA can be understood as an extension of embodying masculinity as the "genius" stereotype is often attributed to those in engineering [9]. Further, research has posited that masculine defaults manifest as seemingly gender-neutral traits, and as such, a high GPA can be considered a masculine default that has been stereotyped and normalized as part of the masculine culture of engineering [19]. Taken together, these results are indicative of the privileged status masculinity occupies within engineering, and so engineering inclusion by those who comprise the numerical majority (i.e., men) is extended to young women whose gender identities conform to these normative ways of being masculine within the culture of engineering.

Importantly, though, women who report more similarity to typical women their age, or feminine typicality, reported more inclusion from female classmates, who are also pursuing engineering. This positive relationship between engineering women's identification with femininity and feeling included by women in their engineering classes can be interpreted as a promising sign of how the field may be improving. As more women (slowly) enter engineering, they may be changing the ways in which femininity is seen. In recent media news, STEM women may be uplifting the status of all women while expressing typically feminine traits (e.g., The Space Gal, Dr. Raven the Science Maven).

Although this study provides new insights into the relationship between engineering women's gender typicality and their perceived relatedness to engineering classmates, there are some limitations. For one, the data for this study are cross-sectional, and at best, the results from the regression analyses can be interpreted as associations. As such, this study does not imply there are any causal relationships. However, future longitudinal studies should examine how women's feminine and masculine typicality measures predict their long-term sense of being included in engineering, and relatedly, their persistence in engineering. While there is a significant effect of cohort (whether the survey was completed in 2019 or 2020) on engineering women's perceived relatedness to male engineering classmates, this study is unable to discern whether this is due to the sudden change in course modality, less in person interactions with peers, or other contributing factors. Further, the young women in this study are self-selected participants of a specific engineering professional organization. Therefore, the results may not be generalizable to all college women studying engineering. Importantly, given the small number of racially/ethnically diverse women in the study, this study was unable to explore potential variations in the relationships by women's race/ethnicity. Hence, future research should examine how gender identities are conceptualized and expressed by engineering women of various intersecting identities, including race/ethnicity and socioeconomic backgrounds, and in turn, how different forms of femininity and masculinity are related to perceived inclusion in engineering.

Implications for practice, particularly for supporting undergraduate women studying engineering, includes assessing the messages prospective students receive during recruitment activities. Additionally, engineering programs should be aware of the language used in classrooms, events, and social media accounts that may further reinforce a masculine image of engineering. In all, this study underscores the importance of exploring measures of gender identity to examine the experiences of women, particularly in highly gendered learning environments such as engineering. As such, this study makes a significant contribution by considering how different measures of gender typicality either bolster or curtail women's sense of comfortability with engineering, which in turn can have important implications for improving women's persistence in engineering, including cultivating more gender inclusive engineering spaces.

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