Equitable Engineering Identity? Race/Ethnicity and Gender Differences in the Predictors of Engineering Identity in First-Year Engineering

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Abstract

This research paper investigates predictors of engineering identity at the beginning of a first-year engineering course. Engineering role identity has been connected to important student outcomes, including academic success, retention, and well-being. Students (*n* = 834) reported their sense of belonging in engineering, cross-racial and cross-gender belonging experiences, engineering self-efficacy, interest in engineering, and engineering identity. Through a series of path analyses, a form of structural equation modeling, we tested the predictive relationships of the measured constructs with engineering identity and investigated differences in these relationships by student race and gender. The model includes engineering identity as directly predicted by self-efficacy, interest, and sense of belonging. Sense of belonging is likewise predicted by self-efficacy and interest, generating additional indirect influences on engineering identity. Finally, a sense of belonging is further predicted by cross-racial and cross-gender belonging experiences. The strong relationships between measures provide insight into the potential for interventions to improve engineering identity in early career engineering students. Future work to analyze the longitudinal change in measures and identity in association with the intervention will further demonstrate variable relationships. Results provide insights into the potential importance of sociocultural interventions within engineering classrooms to improve the engineering climate, engagement, and retention of women and Black, Latino/a/x, and Indigenous (BLI) students.

INTRODUCTION

This research paper investigates predictors of engineering identity at the beginning of a first-year engineering course as part of a larger project to understand continued enrollment in engineering courses. Retaining interested undergraduate students in engineering tracks requires a clear understanding of the predictors and influences on continued enrollment in engineering courses. Particularly, the retention of women of all races/ethnicities, and students who identify as Black, Latino/a/x, or Indigenous (BLI) necessitates changes in engineering ecologies to create more inclusive and equitable engineering environments. Engineering ecology (i.e., interactions within engineering environments) has a direct impact on students' feelings of belonging in engineering courses and in majors, and as such, is a promising space for interventions that address equity issues in students' experiences. Belonging is linked to retention in engineering [1], [2], [3]. Similarly, a student's identity as an engineer influences their continued interest in pursuing engineering [4], [5]. Engineering role identity has been connected to important student outcomes including academic success, retention, and well-being [6]. In this work, we seek to identify relationships between attitudinal variables about belonging and engineering identity.

This study is part of a larger examination of a quasi-experimental intervention designed to address academic equity gaps and, subsequently, the retention of women and BLI students in early engineering courses. The intervention engages social belonging as an avenue to support marginalized students in engineering through narratives that address common challenges of early career engineering courses. As part of intervention efficacy research, students (*n* = 834) reported their sense of belonging in engineering, cross-racial and cross-gender belonging experiences, engineering self-efficacy, interest in engineering, and engineering identity in response to an online survey. Students completed the survey in the first week of classes, before the intervention, and before significant exposure to engineering or college courses.

This study examined the relationship between belonging, self-efficacy, and interest variables to identify differences in the relationships between these constructs for women and BLI students. Our research questions were 1) How well does the proposed model fit the data in predicting engineering identity? 2) How do variable relationships vary for women and BLI students? Through a series of path analyses, a form of structural equation modeling, we tested the predictive relationships of the measured constructs with engineering identity and investigated differences in these relationships by student race and gender groups to answer the research questions.

BACKGROUND AND THEORETICAL FRAMEWORK

Retention of engineering students remains a concern across demographic groups and stages of undergraduate education. In particular, numerous studies have documented that women and BLI students face systemic exclusion and marginalization in engineering environments that reduce their engineering retention [7], [8], [9], [10]. Progress in addressing these issues has been slow, and representation across engineering majors remains uneven, with many engineering education contexts overrepresenting men and White students [9]. Some of the reasons progress is slow is that the issue is multifaceted; the pursuit of engineering is a complex decision with many precursors and influences throughout students' educational pathway, from access to high-quality educational experiences, support to develop STEM career motivation, and cultural and psychological signals regarding who belongs in engineering [7], [8], [10], [11], [12], [13], [14], [15], [16]. Women face bias, harassment, and stereotypes that negatively influence their persistence in STEM subjects [7], [11], [17]**.** These negative influences have long-term impacts, reducing interest and persistence in engineering majors and careers [18], [19], [20]**.** BLI students face systemic racism, discrimination, stereotyping, and microaggressions leading to feelings of isolation and lack of belonging [7], [11], [12], [13], [15], [21], [22], [23], [24]. Particularly at predominately White institutions (PWIs), BLI students face the Whiteness embodied in engineering culture, education, and spaces [25], [26], [27], [28], [29], [30]. And, individuals who hold both of these social identities experience compounding (rather than additive) bias-related challenges [31].

Often retention studies focus on academic performance, which constitutes one of the strongest predictors of continued success and enrollment [7], [32], [33], [34], [35]. However, performance measures alone cannot predict retention in majors, and these measures are confounded with the effects of bias on performance that especially affect women and BLI students [35], [36], [37], [38]. Further, interventions to improve the academic outcomes of women and BLI students often leverage a deficit-based approach, which frames students as the subjects that need to be fixed rather than systems that perpetuate inequities [39], [40]. Ultimately, a deficit framework fails to acknowledge the larger ecological context in engineering that shapes student experiences and the development of their identities as engineers.

Theoretical Framework

Our research questions seek to identify a variable structure for predicting first-year student engineering identity recognition by self and others. Engineering role identity reflects the ways in which students describe themselves as the kind of people who can do engineering [41] and consists of three constructs: interest in the subject, beliefs about the ability to understand and do well in the subject (or competence and performance), and recognition by meaningful others (e.g., peers, instructors, family, etc.)[42], [43]. This framing is based on prior work in science education. Carlone and Johnson [44] developed a framework for science role identity from interviews with women of Color professionals that included performance, competence, and recognition. Later, in translating this framework to undergraduate students in physics, Hazari and colleagues [45] added interest as an important facet of the student experience and developed quantitative measures associated with the four constructs. They found that for undergraduate students, performance and competence were not two separate factors but rather a single factor. This framework has been used across STEM education to describe what it means to take on the role of being a particular type of person and has been linked to several important outcomes including continuation in engineering pathways [5], [41], [46], academic performance [47], [48], and choosing engineering careers [49], [50], [51].

Recognition is an important aspect of engineering role identity [42], [43]. Recognition includes both a self-recognition and other-recognition aspect of being the kind of person who can do engineering work. These beliefs shape the internal dialogue that students have about themselves in the role of an engineer. Students' recognition beliefs do not develop from interactions with insignificant contacts but are rooted in messages from valued others [43]. In this work, recognition is an integral part of our measure of engineering role identity (refer to the Methods section) as it reflects the internalized beliefs shaped by an engineering ecology. This work focuses on students' beliefs about themselves as engineers derived from the influence of others' perceptions of their engineering ability.

Interest is an important aspect of engineering identity and is foundational for pursuing engineering [41], [42], [49]. Engineering interest is an essential part of engineering identity and contributes to persistence in the field [46], [52]. Interest in engineering coursework serves to assist students in overcoming challenges they face during their engineering studies [52], [53], [54], [55]. Further, interest in engineering tasks fosters a sense of belonging in the discipline [56]. Minoritized students who connect engineering coursework to life experiences display increased interest in engineering majors [57]. Recent work has emphasized the importance of interest for the persistence of women in engineering who are also racially minoritized [54].

Students' engineering role identity includes beliefs about their competence in comprehending engineering knowledge and performing engineering tasks. Competence/performance beliefs reflect students' self-efficacy in accomplishing engineering coursework. Self-efficacy represents one's beliefs about their ability to enact behaviors to complete specific goals [58], [59], [60]. Self-efficacy beliefs shape actions and direct effort in pursuit of a desired achievement [60], [61]. Self-efficacy represents a major predictor of success in STEM courses; however, women often score lower on measures of self-efficacy in STEM fields [10], [12], [15], [62], [63], [64], [65]. Differences in self-efficacy are associated with other gender-based disparities in retention, major, and academic performance [13], [18], [20], [66], [67], [68]. Women's self-efficacy tends to decrease through college [69], and is disrupted by school transitions during high school, into college, and between majors during college [70], [71].

Women often have lower self-efficacy in engineering and engineering-related subjects which shapes their belonging and retention [32], [34], [69], [72], [73], [74]. Furthermore, they often have lower self-efficacy than comparable men in required engineering courses, like physics and mathematics [32], [34]. However, this reduced self-efficacy does not accurately reflect women's academic performance which often outpaces their self-efficacy, while contrarily men's self-efficacy often significantly outpaces their performance [32], [34]. Resultantly, men are significantly more confident than women with the same or lower grades in engineering, physics, and mathematics course contexts [34]. Therefore, interventions addressing the ecologies and messages that shape women's self-efficacy beliefs can generate environments that better support women engineers, and narrow the gendered self-efficacy gap observed in these contexts [34]. Mara and associates identified some positive progress in women's self-efficacy in recent years; however, this coincided with a significant decrease in feelings of inclusion over the first year of coursework, consequently demonstrating the important relationship between self-efficacy and belonging [72].

Regarding self-efficacy across racial identity locations, Black and Latino men appear to possess higher general self-efficacy, but lower classroom self-efficacy [75]. Asian students report lower levels of self-efficacy, but these levels were not correlated with academic performance [74]. BLI students tend to have lower self-efficacy than white peers, and socioeconomically disadvantaged BLI students likewise have lower self-efficacy than wealthier students of the same race [76]. Further, intersecting oppression of women and BLI students demonstrated differences in the sources of self-efficacy with increased emphasis on direct experiential learning as important for BLI women [77] However, hands-on learning experiences, such as those in a makerspace, appear to boost self-efficacy for White students more than others, limiting its utility in narrowing self-efficacy gaps [78].

Increasing the social belonging of historically marginalized students can potentially boost their retention and performance; specifically, enhanced belonging may promote the formation of engineering role identity. Social belonging denotes feeling connected to and having positive relationships with peers and institutions [79], [80]. Strong social belonging in college has broad benefits for students, including academic adjustment, academic achievement, and increased retention [56], [78], [79], [80], [81], [82], [83], [84], [85]. Students with belonging uncertainty often have lower engagement with learning activities and less positive learning gains [75], [86]. Degrees of belonging in engineering and other STEM contexts appear to differ based on student race/ethnicity and gender [54], [56], [75], [85], [87], [88], [89]. Specifically, feelings of social isolation strongly contribute to women's choice to leave engineering [62] This lack of belonging has been demonstrated to partially stem from gender-based stereotypes about women's math performance, which then mediates their intent to pursue mathematics in the future [90]. Despite these disparities, it has been found that having positive cross-racial interactions appears to enhance students' sense of belonging without regard to sociodemographic identities [91], [92]. Lower belonging has been associated with lower self-efficacy [78], [93] and more frequent barriers to success in engineering [56], [78], [83], [87]. The combination of the aforementioned factors disproportionately faced by women and BLI students contributes to continued high rates of attrition and reduced graduation outcomes [7], [9], [94], [95], [96], [97], [98], [99].

METHODS

As part of a larger project investigating a psychosocial intervention to improve a sense of belonging, students in an engineering fundamentals course completed a survey about their attitudes and identities. This occurred during the first week of classes before the intervention was delivered. The analyses presented here represent exploratory work to identify variable relationships with engineering identity in preparation for future longitudinal analyses.

Procedures

In the Fall of 2023, students enrolled in an engineering fundamentals course at a large, research-intensive Midwestern university received an email invitation to complete a Qualtrics-based online survey. All sections of the course were invited to participate, and four sections were included as treatment sections and three sections as control or "business-as-usual" sections. The survey was a pre-test given before students participated in a class-based belonging intervention. Future research will use the results from this analysis to assess changes in student attitudes after the intervention. Participants who opened the survey were awarded two extra credit points for the course. All procedures were approved by the Institutional Review Board of the first author.

Participants

Approximately 953 students were enrolled in the participating course sections. Participants who completed less than 90% of the survey were removed from the data, as were students who did not pass a "check" question designed to detect inattentive responders. The final analytical sample included 834 students. Participant gender identity, race/ethnicity, nationality, sexual identity, and disability status are reported in Table 1. Participants self-identified their demographics by selecting from categorical response options including write-in text options. The sample is predominantly men (65%), and white (66%), which reflects the general population characteristics among contemporary U. S. engineering undergraduates. Most participants identified as heterosexual/straight (88%) with 9% identifying as asexual, bisexual, gay, lesbian, pansexual, queer, or another sexual identity. Students reported a range of disabilities, with psychological conditions predominating at 13% of the sample.

Table 1. Demographic Characteristics for Participants.

Race/Ethnicity		Gender		Sexual Identity		Disabilities	
African American/ Black	24	Man	540	Heterosexual/ straight	731	Learning Disability	19
American Indian/ Alaska Native	7	Woman	282	Asexual	7	ADHD	80
Arab, Middle Eastern, or Persian	26	Nonbinary	4	Bisexual	44	Autism Spectrum	14
East Asian	85	Another Gender	1	Gay	3	Physical Disability	26
Southeast Asian	38	PNR	7	Lesbian	9	Chronic illness/ condition	30
Indian, Pakistani, Bangladeshi	110			Pansexual	3	Psychological condition	110
Another Asian Identity	8			Queer	6	Another Disability	7
Mexican American, Chicano, or Mexican	34			Another Sexual Identity	1		
Central American	13			PNR	33		
South American	31						
Puerto Rican	17						
Another Latinx	11						
Native Hawaiian/ Pacific Islander	7						
White/ Caucasian	557						
Another Race/ Ethnicity not listed	7						
PNR	17						

Notes: PNR – prefer not to respond

Measures

Our analyses use gender and BLI status to investigate differences in model relationships based on these sociodemographics. Gender groups used include women and men as defined by the self-reported gender survey item. Nonbinary and another gender respondents were not included in the gender-group analysis due to the significant difference in group sizes. Gender was dummy-coded to Women (1) and Men (0). BLI group was determined by self-reported race/ethnicity. The BLI group includes all participants who selected Black or African American, Latino/a/x, Native American or Native Alaskan, and participants who selected one of these and any other option. All other participants are included in the non-BLI group. BLI status was dummy-coded to BLI (1) and non-BLI (0). We acknowledge that these simplifications do obscure the unique experiences of BLI groups. Further, combining white and Asian masks issues Asian students face in engineering such as model minority biases and microaggressions [100], [101]. However, we find these groups useful in detecting general patterns within our data for further exploration.

Cross-Gender Interactional Belonging was measured with six items with the mean of items used as the analysis variable [102]. The items started with the question: *Since the beginning of the term, have you experienced the following with students at [University] who you perceive to have a different gender than your own?* Responses included items such as: *had guarded, cautious interactions* or *had tense, somewhat hostile interactions.* Participants rated each item on a 5-point Likert frequency scale: Never (1), Seldom (2), Sometimes (3), Often (4), or Very Often (5). The items demonstrated acceptable internal reliability (Cronbach's $\alpha = .73$).

Cross-Race Interactional Belonging was measured with six similarly worded items with the mean of these items used as the analysis variable [102]. The items start with the question: *Since the beginning of the term, have you experienced the following with other students at [University] from a racial/ethnic group other than your own?* An example item is: *had intellectual discussions outside of class or studied or prepared for class.* Response options were an identical 5-point Likert frequency scale. The items demonstrated marginal internal reliability (Cronbach's $\alpha = .64$).

Belonging in Class was measured with four items, the mean of which constituted the variable for analysis. These items were adapted for the engineering context [103]. The item stems read: *Take a moment and think about your experiences and feelings related to engineering. To what extent do you agree with the following statements?* An example item is: *I feel comfortable in engineering*. Participants responded to these items with a four-point Likert agreement scale: Strongly disagree (1), Disagree (2), Agree (3), Strongly Agree (4), or I haven't had any engineering courses (system-missing). The items demonstrate acceptable internal reliability (Cronbach's $\alpha =$ .71).

Self-efficacy was measured with six items with the mean used as the variable for analysis. Representative items include: *If I study, I will do well on a test in an engineering course* or *I am capable of helping my classmates with engineering coursework.* Items were adapted to specify engineering from similar physics items [73] Participants responded on the following four-point scale: NO! (1), no (2), yes (3); and YES! (4). These response options have strong validation arguments in educational contexts [104]. The items demonstrate moderately strong internal reliability (Cronbach's $\alpha = .77$).

Interest measured students' interest in, positive affect regarding, and propensity to wonder about engineering topics. It was measured with five items, the mean of which was the analytic variable. Again, items were adapted to specify engineering contexts [105], [106], [107]. A sample item is *I enjoy learning new things about engineering*. Participants responded to these items via a five-point Likert agreement scale: Strongly disagree (1), Disagree (2), Agree (3), or Strongly Agree (4). The items demonstrated moderate internal reliability (Cronbach's α = .74).

Engineering identity recognition was measured with five items. The mean of the items was the variable for analysis. Items were adapted from a similar physics measure to specify an engineering context [42], [106]. Example items are: *My peers see me as an engineering kind of person.* Participants responded on a four-point Likert-type scale of NO! (1), no (2), yes (3); or YES! (4) [106]. The items demonstrate strong unidimensionality (Cronbach's α = .80).

Positionality

The author team includes a subset of researchers from the larger project [108]. The project as a whole represents the researchers' combined interest in diversity, equity, inclusion, and justice in STEM academic spaces generally and engineering spaces particularly. The intervention project and the research presented here focus our interests on specific groups of which some researchers are members and others are not. We as authors hold our positions of privilege within academia in mind as seek to understand the perspectives, attitudes, and experiences of current undergraduate students. As a group, we are highly educated, predominantly White, with some Black and Latinx researchers, and include men, women, and gender-minorities. Our educational experiences span engineering, higher education, and psychology. The diversity of our backgrounds provides a wealth of resources for conducting and interpreting our larger research project. Further, we hold the necessity and importance of quantitative analyses in conflict with our value of individual experience which can only be investigated through qualitative means. We seek to identify patterns that represent probabilities of experiences (and that do not represent every individual) that can be addressed to improve overall patterns of persistence and degree completion for marginalized and minoritized students.

ANALYSIS

Descriptive statistics including means, standard deviations, kurtosis, skew, and bivariate correlations were calculated using SPSS. The main analyses used path analysis in a structural equation modeling framework with full information maximum likelihood estimation to account for missing values. Path analyses were conducted in Stata v.17. Path analysis extends multiple regression techniques by providing for multiple dependent variables that are set in a specified structure [109], [110]. Researchers specify the proposed structure of the data in an analytic model that is then tested to determine how well the hypothesized relationships in the model represent those in the empirical data (i.e., model fit) and how well the proposed model explains variation in the outcome variable. Path analysis is particularly useful when variables are thought to mediate other relationships in the model and provides the opportunity to test the model when the model relationships may be different based on subgroups [110]. In this project, we identify the variable relationships with engineering identity via the model proposed in Figure 1. This model is based on engineering role identity and includes engineering identity as directly predicted by self-efficacy, interest, and sense of belonging. Sense of belonging is likewise predicted by self-efficacy and interest, generating additional indirect influences on engineering identity. Finally, student sense of belonging is further predicted by cross-racial and cross-gender interactional belonging experiences.

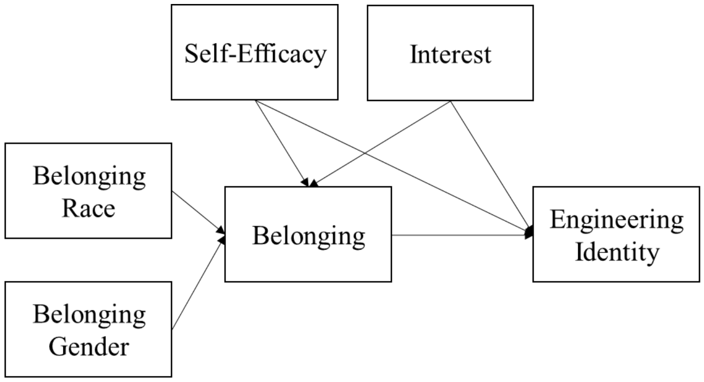

Figure 1. Proposed Path Model of Variable Associations

We assessed the overall fit of the model with several fit statistics including the Tucker-Lewis index (TLI), comparative fit index (CFI), root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). The coefficient of determination (CD) corresponds to the percent of variability in the outcome variable accounted for by the model with higher values indicating greater variance explained. Established guidelines for each fit statistic indicate models that meet the following fit the data well: non-significant chi-square, TLI greater than .95, CFI greater than .95, RMSEA less than .07 (using a 95% confidence interval [CI]), and SRMR less than .05 [111].

RESULTS

The descriptive statistics and bivariate correlations are presented in Table 2. The variables have a strong central tendency with significant correlations. Skewness and kurtosis lie well within acceptable limits. The bivariate correlations do not demonstrate multicollinearity.

Table 2. Descriptive Statistics and Bivariate Correlations

Variable	Mean	SD	Skewness	Kurtosis	1	2	3	4	5
1. Belonging Race	3.25	0.59	-0.15	-0.16	-				
2. Belonging Gender	2.99	0.66	0.14	-0.61	.59**	-			
3. Self-Efficacy	2.78	0.44	0.49	0.32	.19**	.18**	-		
4. Interest	3.54	0.42	-1.08	1.76	.09*	.09**	.25**	-	
5. Belonging	3.29	0.41	0.11	-0.26	.17**	.19**	.46**	.42**	-
6. Engineering Identity	3.33	0.45	-0.17	-0.59	.18**	.14**	.36**	.39**	.56**

Notes: ** $p < 0.01$ level. * $p < 0.05$ level (2-tailed).

Overall Model

The overall model fits the data well ($\chi^2(2) = 5.00$, $p = .082$; RMSEA = .043, CI-LB = .000, CI-UB = .091; CFI = .996; TLI = .980, CD = .364). Path analysis identified significant relationships ($p < .05$; Table 3) for all variable connections except for that between a sense of belonging and racial interactional belonging experiences. Self-efficacy and interest had particularly strong relationships with belonging in class which in turn had a strong relationship with engineering identity. Next, we sought to identify differences in the variable relationships based on gender and BLI status.

Gender Comparison Model

A second analysis by gender group demonstrates differences in the strength and significance of the structural relationships. The gender group model maintained very high model fit ($\chi^2(4) = 7.97$, $p = .093$; RMSEA = 0.049, CI-LB = .000, CI-UB = .099; CFI = .994; TLI = .972, CD = .355). The men group held the same significance patterns as in the overall model. However, for women, the relationships between cross-gender experiences and a sense of belonging and between self-efficacy and engineering identity were no longer significant.

BLI Comparison Model

A third analysis by BLI status demonstrated differences in the strength and significance of the structural relationships similar to the gender comparison model. The BLI model maintained very high model fit indices ($\chi^2(4) = 9.63$, $p = .047$; RMSEA = .059, CI-LB = 0.006, CI-UB =.107; CFI = .992; TLI = .962, CD = .363). The BLI group held similar differences to the women group with the relationships between cross-gender experiences and a sense of belonging and between self-efficacy and engineering identity no longer significant. The non-BLI group had the same significance patterns as the overall model.

Table 3. Path Model Coefficients

Group	Dependent	Independent	S.C.	S.E.	*z*	*p*	95% C.I. [LB, UB]
Overall Model							
All	Belonging in Class	Self-Efficacy	0.36	0.03	12.62	< .001	[0.30, 0.42]
		Interest	0.32	0.03	11.22	< .001	[0.26, 0.37]
		Belonging Race	0.04	0.04	0.93	0.353	[-0.04, 0.10]
		Belonging Gender	0.04	0.04	2.13	0.033	[0.01, 0.15]
	Engineering Identity	Self-Efficacy	0.12	0.03	3.69	< .001	[0.05, 0.18]
		Interest	0.18	0.03	5.93	< .001	[0.12, 0.24]
		Belonging in Class	0.43	0.03	13.54	< .001	[0.36, 0.49]
Gender Comparison Model							
Women	Belonging in Class	Self-Efficacy	0.24	0.05	4.60	< .001	[0.14, 0.34]
		Interest	0.43	0.05	9.17	< .001	[0.34, 0.52]
		Belonging Race	0.06	0.06	0.98	0.325	[-0.06, 0.17]
		Belonging Gender	0.03	0.06	0.50	0.616	[-0.09, 0.15]
	Engineering Identity	Self-Efficacy	0.05	0.05	0.95	0.341	[-0.05, 0.15]
		Interest	0.17	0.06	3.07	0.002	[0.06, 0.28]
		Belonging in Class	0.45	0.06	8.16	< .001	[0.34, 0.56]
Men	Belonging in Class	Self-Efficacy	0.38	0.04	10.6	< .001	[0.31, 0.45]
		Interest	0.27	0.04	7.58	< .001	[0.20, 0.34]
		Belonging Race	0.03	0.05	0.76	0.446	[-0.05, 0.12]
		Belonging Gender	0.08	0.05	1.98	0.048	[0.00, 0.18]
	Engineering Identity	Self-Efficacy	0.14	0.07	3.68	< .001	[0.07, 0.22]
		Interest	0.2	0.13	5.50	< .001	[0.13, 0.28]
		Belonging in Class	0.4	0.04	10.35	< .001	[0.33, 0.48]
BLI Comparison Model							
BLI	Belonging in Class	Self-Efficacy	0.24	0.10	2.44	0.015	[0.05, 0.43]
		Interest	0.37	0.09	3.98	< .001	[0.19, 0.55]
		Belonging Race	0.11	0.10	1.11	0.268	[-0.08, 0.30]
		Belonging Gender	0.03	0.10	0.61	0.541	[-0.13, 0.25]
	Engineering Identity	Self-Efficacy	0.11	0.09	1.27	0.204	[-0.06, 0.30]
		Interest	0.23	0.09	2.50	0.012	[0.05, 0.42]
		Belonging in Class	0.46	0.09	5.28	< .001	[0.29, 0.63]
Non-BLI	Belonging in Class	Self-Efficacy	0.70	0.03	12.42	< .001	[0.31, 0.43]
		Interest	0.32	0.03	10.58	< .001	[0.26, 0.37]
		Belonging Race	0.02	0.04	0.59	0.554	[-0.05, 0.10]
		Belonging Gender	0.08	0.04	2.03	0.042	[0.00, 0.15]
	Engineering Identity	Self-Efficacy	0.11	0.03	3.28	0.001	[0.04, 0.18]
		Interest	0.18	0.03	5.46	< .001	[0.11, 0.24]
		Belonging in Class	0.43	0.03	12.66	< .001	[0.36, 0.49]

Notes: *All coefficients are standardized, and the size of the effect may be interpreted the same as Cohen's d effect sizes.*

DISCUSSION

In answer to our first research question, the overall model of variable relationships very strongly represents the data and explains approximately 36% of the variation in engineering identity. The gender and BLI group models also explain 36% of the variation in the outcome. The strong model fit statistics for all three analyses demonstrate the usefulness of the model to represent variables related to engineering identity in early undergraduate career engineering students. The significant results for self-efficacy, interest, and belonging in the overall model, which is predominated by White men, demonstrate the importance of these variables [52], [53], [54], [68], [72], [79], [81], [82]. The strong relationships between self-efficacy and interest with belonging and engineering identity reflect existing literature [1], [54], [56], [83], [84], [87], [89], [103], [112]. Similarly, the strong relationship between belonging and engineering identity supports existing literature [41], [42], [49], [56], [78], [79], [80], [81], [82], [83], [84], [85], [93]. The lack of significance for cross-race interactional belonging in all models potentially relates to the predominately white student population in engineering. The non-significance of institutional belonging based on race-related interactions may not translate to in-class belonging beliefs. The overall model provides insight into the potential for attitudinal interventions to support engineering identity growth in first-year engineering students. For example, efforts to improve self-efficacy, interest, and belonging could support student's engineering identity.

Our second research question seeks to identify differences based on gender and BLI status. The gender and BLI analyses demonstrate a pattern in which the majority groups (men and non-BLI students) maintain the same significance patterns as the overall model while minoritized groups (women and BLI students) exhibit distinct significance patterns. The overall model results mask the important distinctions in the model for women and BLI students. The difference highlights the importance of engineering education research identifying the diversity of experiences and attitudes present in engineering students [55], [56], [113], [114], [115], [116], [117], [118]. Reliance on overall measures masks the significant differences between groups of students.

Particularly self-efficacy was not significantly related to engineering identity for women and BLI students. Self-efficacy predicts STEM course success generally; however, women tend to score lower on self-efficacy measures [10], [12], [15], [62], [63], [64]. The non-significant relationship between self-efficacy and engineering identity adds to the list of gender-based disparities in engineering [18], [19], [20], [67], [68]. Stereotype threat pressures women's self-efficacy, hindering STEM field choice and the loss of the benefits of strong self-efficacy such as occupational and academic self-efficacy [61], [119], [120]. Race/ethnicity may further influence gender-based discrepancies in self-efficacy [72], [77].

The non-significance of self-efficacy for the BLI group demonstrates race/ethnicity-based differences in self-efficacy [74], [76], [78], [121], [122], [123]. The context-specific fluctuations in self-efficacy may particularly harm self-efficacy beliefs for Latino and African American men in the engineering classroom [75]. Multiple levels of oppression may further suppress self-efficacy beliefs for BLI students including differences in sources of self-efficacy and stereotype threat [75], [77], [78].

The gender belonging variable was not significant for women or BLI groups demonstrating another difference from the overall model analysis. The predominance of men in the BLI sample may skew measures of significance for gender belonging differences at the intersection of oppression of women and BLI students [54], [75], [88], [89], [124]. In the gender model, men benefited from interactional cross-gender belonging effects on their overall sense of in-class belonging. Men's sense of belonging may reflect their high representation in engineering spaces [9].

The model demonstrates the importance of self-efficacy, interest, and belonging to the developing engineering identity of first-year engineering students. Each of these supports existing literature linking these variables to engineering identity which can serve as an important source of persistence in engineering [46], [54], [125]. Future research should continue to test these relationships.

Future Work and Limitations

As an analysis of pre-intervention data, the results presented here are the first analysis in investigating the engineering role identity model in a first-semester, first-year engineering course. Future longitudinal research will examine the effect of the intervention on attitudes and engineering identity development with post-intervention data from this early career course. Within these analyses, we will further explore the differences in model behavior for women and BLI students. The sample sizes for women and BLI students limit our ability to address more complex research questions such as the intersection between gender and race as well as differences in BLI experiences. While minoritized in engineering, BLI students are not a monolith, and the term encompasses notably different experiences in the education system. Similarly, gender designations such as women are not monolithic and require disaggregation. The investigation of the intersection of oppressed or minoritized identities in engineering and the relationship between gender and race-based interactional belonging to in-class belonging beliefs should be further explored. Disaggregation of groups would further clarify variable relationships, particularly for differences around self-efficacy in Asian students [74], [126] and the influence of socioeconomic status [76]. Additional student groups in engineering who face belonging challenges such as first-generation students or students with disabilities should be included. Alternative analyses in future research and qualitative research may be better able to address some of these limitations.

CONCLUSIONS

In this paper, we investigated the predictors of engineering identity among students embarking on their first-year engineering course. In prior literature, significant correlations have been shown to exist between engineering role identity and important student outcomes, such as academic success, retention, and well-being. In this study, we scrutinized the predictive relationships among these factors and engineering identity. These results provide insights into the potential importance of sociocultural interventions within engineering classrooms to improve the engineering climate, engagement, and retention of women and BLI students. We also explored potential variations in these relationships based on students' race and gender. The proposed model indicates that engineering identity is directly correlated with self-efficacy, interest, and a sense of belonging. Moreover, sense of belonging is predicted by self-efficacy and interest, creating additional indirect linkages to engineering identity. In addition, cross-racial and cross-gender interactional belonging experiences further predict a sense of belonging in most engineering students surveyed. The robust connections observed between these variables suggest the potential efficacy of attitudinal interventions to enhance engineering identity among early career engineering students. However, the differences observed in the gender and BLI group models emphasize the importance of identifying differing structures to reflect the diversity of experiences in engineering. The overall model fit the data well, while masking important distinctions for women and BLI students. Future research examining longitudinal changes in these measures and identity in response to interventions will provide a deeper understanding of variable relationships. These findings shed light on the potential significance of sociocultural interventions within engineering classrooms to enhance the overall engineering environment, engagement, and retention, particularly for women and underrepresented minority students.

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