Gender and Engineering Identity among Upper-Division Undergraduate Students

Leigh C. Hamlet[1]; Arkajyoti Roy, Ph.D.[2]; Giovanna Scalone, Ph.D.[3]; Regina Lee, Ph.D.[4]; Cristina Poleacovschi, Ph.D., M.ASCE[5]; and Jessica Kaminsky, Ph.D., M.ASCE[6]

Abstract: The construction industry's long-term health depends upon continued efforts to understand historically excluded students' attrition from engineering programs. For women, lack of identification with engineering may motivate their departure. Because professional persistence relates to engineering identity, it benefits attrition interventions to understand this identity development. Focusing upon students demonstrating some persistence in engineering, this research examines if and how engineering identity differs across gender among upper-division undergraduates. Surveying 11 American public university civil and construction engineering programs, the authors capture how central engineering is to self-concept, how positively students view engineers and perceive others to view engineers, and how students feel they belong. Using structural equation modeling, the authors find that among upper-division students and compared with cis men, cis women more strongly define themselves as engineers, are more confident of their place among fellow engineers, and feel more positively about engineers. A stronger engineering identity may help cis women cope with marginalization and may be limited to the upper-division undergraduate years. This study offers guidance for sustaining upper-division cis women's strong engineering identity. **DOI: 10.1061/(ASCE)ME.1943-5479.0000876.**

Introduction

It is well-documented that engineering and construction higher-education programs and industry workforces lack diversity. Illustratively, for the construction industry, a recent figure from the US Bureau of Labor Statistics suggested that approximately 10% of construction professionals in the country are women (US Bureau of Labor Statistics 2019). For the academic community, women's receipt of bachelor's, master's, and doctoral degrees in civil engineering has stalled at approximately 20% (Appelhans et al. 2019), which could be argued as satisfactory (Hickey and Cui 2020) but does not suggest progress. In response to these gender differences and other disparities, research efforts have focused upon explaining underlying causes (Tao and McNeely 2019), the ensuing economic, social, and individual repercussions (Appelhans et al. 2019; Manesh et al. 2020), and possible ways to subvert these historical trends (Faulkner 2007; Petray et al. 2019; Prybutok et al. 2016; Shrestha et al. 2020).

For the construction industry specifically, improving workforce diversity not only benefits the innovation, productivity, and financial performance of organizations (Petray et al. 2019; Watson and Froyd 2007), but also addresses the global skill shortage (Sunindijo and Kamardeen 2017). The long-term health of the industry depends upon continued efforts to understand issues of attraction and retention of underrepresented groups [i.e., groups not characterized by able-bodied white men (Powell and Sang 2013)], particularly during college. Earning an undergraduate degree is the beginning of many professional careers and is a potentially important determinant of long-term retention in the construction industry. For women in the construction industry, earning a college degree in related fields significantly influences their satisfaction with their current employers, their intentions to remain with these employers, and their overall long-term careers in the industry (Malone and Issa 2013; Naoum et al. 2020).

The importance of engineering degree programs in industry retention has also been emphasized by researchers studying the attrition of underrepresented students from engineering (Appelhans et al. 2019; Watson and Froyd 2007). Some of this research foregrounds the agentive role of engineering departments in this departure by relabeling underrepresented students as excluded identities (Appelhans et al. 2019; Walden et al. 2018). The use of identities in this term is apropos, given that beyond acquiring requisite skills for their careers, undergraduate students also undergo disciplinary development and begin to foster their professional identities during college (Meyers et al. 2012). Because identity is a key informant of experience (hooks 1981; Spelman 1988; Tate and Linn 2005), its formation is imperative for students' experiences and retention in degree programs (Seymour 1997; Stevens et al. 2005). Given the centrality of engineering identity formation to the retention of

[1]Graduate Research Assistant, Dept. of Civil and Environmental Engineering, Univ. of Washington, 201 More Hall, P.O. Box 352700, Seattle, WA 98195 (corresponding author). ORCID: https://orcid.org/0000-0003-0712-4199. Email: lhamlet@uw.edu

[2]Assistant Professor, Dept. of Management Science and Statistics, Univ. of Texas at San Antonio, 5 Paseo Del Norte, San Antonio, TX 78249. ORCID: https://orcid.org/0000-0003-0348-9297. Email: arkajyoti.roy@utsa.edu

[3]Postdoctoral Research Associate, Dept. of Human Centered Design and Engineering, Univ. of Washington, 428 Sieg Hall, P.O. Box 352315, Seattle, WA 98195. ORCID: https://orcid.org/0000-0003-0323-1608. Email: gscalone@uw.edu

[4]Senior Lecturer, Dept. of Gender, Women, and Sexuality Studies, Univ. of Washington, B110 Padelford Hall, P.O. Box 354345, Seattle, WA 98195. ORCID: https://orcid.org/0000-0002-8637-3558. Email: rylee001@uw.edu

[5]Assistant Professor, Dept. of Civil, Construction, and Environmental Engineering, Iowa State Univ., 813 Bissell Rd., Ames, IA 50011. Email: poleacov@iastate.edu

[6]Assistant Professor, Dept. of Civil and Environmental Engineering, Univ. of Washington, 201 More Hall, P.O. Box 352700, Seattle, WA 98195. ORCID: https://orcid.org/0000-0002-1340-7913. Email: jkaminsk@uw.edu

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underrepresented students in construction fields and the signal importance of increasing diversity to the development of the field, this research focuses upon the university years and the role of gender in students' "being and becoming" engineers (Carlone and Johnson 2007; Chachra et al. 2008).

To this end, the authors used structural equation modeling (SEM) to isolate and assess the extent of self-identification with engineering across gender among upper-division students from 11 American public university civil and construction engineering programs. In light of the findings, this paper argues that cis women identify with engineering to a stronger extent than cis men, a phenomenon that may be unique to the upper-division undergraduate years: at that point in their program, cis women have demonstrated some persistence in engineering and may be able to manage marginalization due to their violation of gender norms. This research may help inform the educational support of and curriculum for upper-division engineering students to augment and sustain strong engineering identities among cis women.

Although the findings of this paper are from a data set of exclusively civil and construction engineering students, due to the lack of discipline-specific studies on diversity in engineering programs the authors link the findings to the available broader-scoped literature. Many of these studies include civil engineering students (e.g., Meyers et al. 2012; Prybutok et al. 2016; Seymour 1997), making their claims representative and relevant to the field; however, their wide range can also dilute concepts and overlook nuances relevant to each discipline's diversity issues. A strength and unique feature of this paper is its concentration on civil and construction engineering students, making it particularly germane to the profession and suggesting a need for similar framing of future related research.

Engineering Identity

Given the aforementioned studies, the formation of engineering students' professional identity—although only one component of students' broader development of their sense of self (Carlone and Johnson 2007; Prybutok et al. 2016)—is nonetheless a useful framework for addressing issues of retention in construction and engineering (Morelock 2017; Pierrakos et al. 2009; Tonso 2007). Research has shown that aligning students' self-image to that of professionals improves their retention in science, technology, engineering, and mathematics (STEM) (Matusovich et al. 2010; Meyers et al. 2012). Here, the authors define students' self-image as it relates to their engineering identity, which encompasses what it means to be an engineer in terms of characteristics, knowledge, and activities (Hatmaker 2012; Morelock 2017). In this research, the authors refer to the double-sidedness of identity (Skinner et al. 2001; Stevens et al. 2005), a term highlighting the simultaneity of internal and external identity formation, to capture students' development of self in context: indeed, "identity is something experienced (as in 'I belong') but also something bestowed and maintained by others (as in 'to us, you belong')" (Stevens et al. 2005).

Theoretical Framework

Within the literature, there are numerous definitions and frameworks for engineering identity (Morelock 2017). The authors use a theoretical framework of engineering identity stemming from the multidimensional inventory of Black identity (Chachra et al. 2008; Sellers et al. 1997) and from an adaptation of a group identification scale (Brown et al. 1986; Chachra et al. 2008; Hinkle et al. 1989). The final framework comprises four constructs. These subscales include notions of centrality, or the extent to which students define themselves as engineers; private regard, or the extent to which students feel positively or negatively about engineering and engineers; public regard, which is the extent to which students perceive others feel positively or negatively about engineering and engineers; and group identification, defined as the extent to which students feel they belong in engineering (Chachra et al. 2008; Settles et al. 2016). To date, this specific framework has only been used to study engineering identity of lower-division undergraduate students across multiple engineering disciplines (Chachra et al. 2008). It follows that this framework should be applied to and validated for upper-division undergraduate engineering students, which the authors restrict to the civil and construction engineering discipline to best inform the industry's retention efforts.

Gender and Engineering Identity

The role of gender has been identified as a critical component of engineering identity studies (Tonso 2007). For example, professional persistence is linked to engineering identity (Meyers et al. 2012). Historically, women have left engineering in greater percentages than men (Fouad et al. 2011). Despite demonstrated technical skills, a lack of identification with engineering may motivate women to leave engineering (Godwin and Potvin 2017; Seymour 1997; Sheppard et al. 2015).

To be precise, the authors use the term cisgender to refer to individuals whose gender identity matches their sex assigned at birth (Aultman 2014). Previous engineering identity work often lacks this semantic precision, which is a contribution of this paper and its proposed survey tool for the promotion of more specific targeting of diversity program efforts and more inclusive diversity rhetoric. Although the number of transgender students in this study is too low to provide sufficient power for quantitative study, this proportion likely mirrors the actual state of the construction industry (Chan 2013) and gives the authors confidence in comparing with previous engineering identity work.

In the literature, the role of gender as it relates to engineering identity depends upon the theoretical framework and definitions (Morelock 2017). Within a study utilizing the engineering identity framework used here, it was observed that among first- and second-year engineering US undergraduate students, there was no statistically significant difference in the extent of identification with engineering between men and women. That study also suggested that men and women may have differing understandings of what constitutes a professional engineering identity (e.g., in terms of activities) and requires further research (Chachra et al. 2008).

In contrast, another study employing a differing framework but disaggregating by gender and grade level suggested that first-year women were the least likely to self-identify as engineers and that at all grade levels, a higher percentage of men self-identified as engineers compared with women (Meyers et al. 2012). Although women in general are thought to enter college with lower self-efficacy than males (Besterfield-Sacre et al. 2001), gender has also been found to not be a significant predictor of persistence in engineering when considered against grades in introductory STEM courses, at least at highly selective institutions (Strenta et al. 1994). However, academic achievement does not fully explain persistence because women leaving engineering are performing as well as those populations that decide to stay (Cech et al. 2011; Seymour 1997; Shi 2018), regardless of the institution type. In sum, the gendered role of engineering identity in retention remains unclear and requires further empirical investigation.

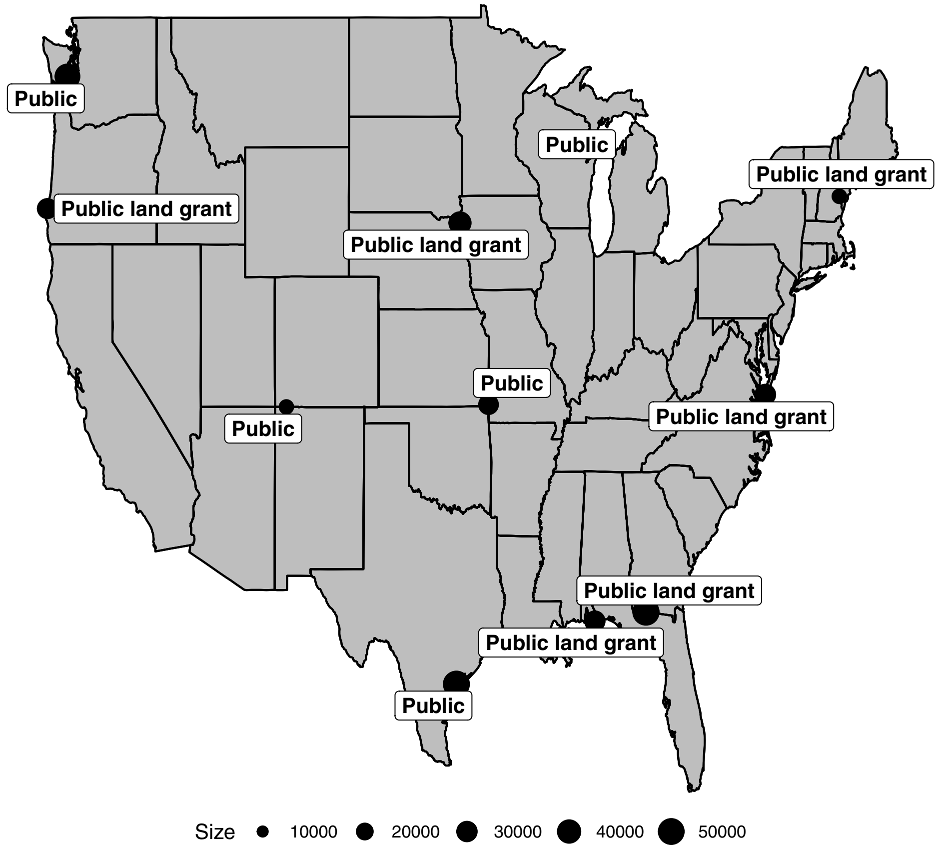

Fig. 1. Approximate locations and sizes of the 11 sampled public universities with upper-division student data, labeled by type.

Purpose

This research measures the engineering identity of upper-division undergraduate engineering students and quantifies the differential extent of self-identification with engineering for cis women as compared with cis men. The authors ask the following questions:

- Does gender, and specifically cisgender identity, affect the extent of self-identification with engineering among upper-division American undergraduate engineering students?
- How does engineering identity differ across gender in the ways of centrality, public regard, private regard, and group identification among upper-division American undergraduate engineering students?

Methods

Data Collection

Twelve public universities distributed across the US participated in the survey during 2019; one institution only included lower-division student participants and was therefore removed from this analysis. Six of these institutions were public land-grant universities. The average student population (including graduate students) was approximately 31,000 students. The approximate locations and student population, as well as university type, are displayed in Fig. 1.

Institutional review board approval was received from the University of Washington. In total, 377 surveys were collected; 14 out of the 391 students who participated requested to have their responses destroyed. The minimum number of surveys from any university was 12, and the largest was 87 surveys, with an average of 31 surveys. The authors do not make claims about any particular university or region; the surveys were combined to generalize the findings across American public universities because it was statistically confirmed that university-level effects did not materially change the results herein.

The survey contained 29 Likert-scale items, as well as several qualitative questions. Demographics were also collected, including gender and sex information (Tables 1 and 2). The Likert-scale items and demographics questions took approximately 10 min to complete, and this study only focuses upon these items. The 29 Likert-scale items were identical with those originally created by Chachra et al. (2008) and are listed in the Appendix, along with the abbreviated versions of the items used in the analysis. These Likert-scale items were scored on a scale from −3 (strongly disagree) to 3 (strongly agree); except for the noted reversed scale items, the survey items were structured such that the higher the response score, the stronger the engineering identity (i.e., the greater the extent of self-identification with engineering).

Table 1. Self-disclosed genders of sampled students

Response	Count	Proportion (of 328 upper-division civil engineering survey respondents)
Cis woman	92	0.28
Cis man	223	0.68
Transgender or prefer not to respond	13	0.04

Table 2. Demographics for cisgender students

Demographic characteristic	Predominant demographic makeup	Cis women			Cis men		
		Count	Total[a]	Proportion	Count	Total[a]	Proportion
Age	18–22	85	92	0.92	183	222	0.82
Sexual orientation	Heterosexual	82	90	0.91	198	209	0.95
Race	White (including Middle Eastern)	69	89	0.78	169	210	0.80
Socioeconomic status	> USD 100,000	43	81	0.53	85	184	0.46
Ethnicity	Not Hispanic or Latino	83	91	0.91	195	215	0.91
Disability	No disability	89	91	0.98	209	221	0.95
Religious affiliation	Other Christian religion	39	90	0.43	73	208	0.35
Family bachelor's degree	Yes	80	91	0.88	149	222	0.67

[a]The Total column is the number of upper-division respondents of that gender willing to provide that demographic information, assumed to be sampled from a population of upper-division cisgender students willing to provide those demographics.

Data Cleaning

Using the sociodemographic information collected on self-reported gender and sex, responses were filtered to include only cisgender individuals; other genders were not analyzed here due to the small sample sizes of those groups (13 students) (Table 1). Furthermore, the authors only retained students who were juniors or seniors, who considered themselves to be engineering students, and who identified as civil (including architectural and environmental) or construction engineering students. Despite different nomenclature of the civil departments across the sampled universities, and despite undeclared majors for six students, the authors were confident in grouping students across these institutions based upon students' enrollment in a construction-related course at the time of the survey. Overall, these criteria resulted in removing 61 respondents from the data set. One additional student was not included in the analysis due to substantial missingness of demographic information. The final sample was comprised of 315 upper-division civil and construction engineering undergraduate students from 11 universities who were willing to answer at least some of the survey items. Single imputation was used to fill in the missing responses (0.3% missingness, assumed to be missing at random). Future work should explore the experiences of the students excluded from this analysis using different research designs.

As stated previously, the original survey items were scored on a scale ranging from −3 to 3, excluding zero. For this analysis, the scale was recoded to range from 1 to 6. Each of the survey items was treated as an ordinal variable with six levels. However, for the survey items that did not have responses at each level, the authors collapsed the levels with zero responses. This step retained the ordinal structure of the variables, and because the authors were not interested in the finer movement from level to level but rather the direction and overall significance of the difference between the scores of the average student across gender, this data cleaning step was not believed to be a marked loss of information.

Validation of Selected Theoretical Framework and Measurement Tool

The authors sought to validate the theoretical framework designed by Chachra et al. (2008) because it had not been previously done and published, nor had the framework been applied to study upper-division undergraduate students' engineering identity. An exploratory factor analysis (EFA) was used to identify latent engineering identity factors (Thompson 2004) and compare them with the four factors defined by Chachra et al. (2008). EFA seeks to discover the number of factors without specifying items to certain factors (Bartholomew et al. 2008, p. 289). This flexibility allowed the authors to consider moving items to different constructs while still being primarily guided by the theory drawn from Chachra et al. (2008). Given the ordinal nature of the data, the authors performed the analysis by computing a polychoric correlation matrix and creating a scree plot of eigenvalues to identify the desirable number of latent factors. Upon identifying four factors, an oblique rotation (Osborne 2015) was used for the polychoric correlation matrix to produce the factor loadings. The authors removed cross-loading items, or those which loaded similarly onto two or more factors (i.e., for a single latent factor, if its highest-magnitude loading was at least double its second highest loading, the factor was considered unidimensional). For this analysis, and for the confirmatory factory analysis (CFA), a standardized factor score (rounded to the nearest 10th digit) of 0.5 was the threshold for loading the survey items onto the latent factors. Table 3 presents the EFA results, displaying only the items which loaded above the threshold.

As indicated in Table 3, the items and constructs demonstrated good internal reliability. For example, the four constructs' Cronbach's alpha scores were greater than an accepted threshold of 0.7 (Gliem and Gliem 2003). Using the reliable measurement structure specified by the EFA, measurement invariance was confirmed across gender, the characteristic of interest. After an initial test suggested that measurement invariance was violated ($\Delta\chi^2 = 85.9$, degrees of freedom (df) = 61, and p-value $= 0.019$), the authors removed the sixth public regard item ("Viewed as an asset") and achieved measurement invariance ($\Delta\chi^2 = 64.8$, $\mathrm{df} = 58$, and p-value $= 0.25$), suggesting comparisons across gender are meaningful and valid (Sass 2011). To further substantiate cross-gender comparisons and in response to Chachra et al.'s (2008) comment on potentially differing definitions of engineering by sex, the authors qualitatively coded students' descriptions of prototypical engineers. No substantive differences in these descriptions were uncovered.

A CFA was completed using this new measurement structure (depicted in Fig. 2) and a diagonally weighted least-squares estimator (Li 2016). For the purpose of model identification, because private regard only has three items, it was required that the factor loadings of its "I often regret" and "I am proud" items be constrained as equal because their error variances were uncorrelated, and there was no theoretical justification against this equivalence (Kenny 2020). The CFA results are given in Table 4, and the model-implied correlation matrix is presented in the Appendix. The construct reliability scores as represented by composite reliability, with a benchmark of 0.80 (Brunner and SÜβ 2005), supported the internal consistency of model (Bollen 1989). Each construct's average variance extracted was at least 0.5 (Fornell and Larcker 1981), further establishing construct reliability. Other fit indices such as the robust root-mean square error of approximation (RMSEA) of 0.079 [less than 0.08 indicated a good fit (MacCallum et al. 1996)] and standardized root mean squared residual (SRMR) of

Table 3. Exploratory factor analysis

Latent construct	Code	Item	Standardized factor loading	Item reliability (R^2)	Construct reliability (Cronbach's alpha)	Variance explained (%)
Centrality	C1	Very little to do[a]	0.56	0.32	0.77	9.06
	C2	Part of self-image	0.77	0.59		
	C4	Unimportant to my sense[a]	0.71	0.51		
	C8	Not major factor in social[a]	0.47	0.22		
Private regard	PrR2	I am happy	0.65	0.43	0.78	6.97
	PrR4	I often regret[a]	0.72	0.51		
	PrR5	I am proud	0.56	0.31		
Public regard	PuR1	Considered good	0.56	0.32	0.79	13.22
	PuR2	Others respect	0.77	0.60		
	PuR3	More ineffective[a]	0.55	0.30		
	PuR4	Not respected by society[a]	0.65	0.42		
	PuR5	Viewed in positive manner	0.73	0.54		
	PuR6	Viewed as asset	0.46	0.21		
Group ID	GI1	I identify	0.70	0.49	0.85	12.71
	GI2	Glad to belong	0.45	0.25		
	GI5	Important part on campus	0.52	0.27		
	GI6	Fit in well	0.75	0.56		
	GI9	Feel strong ties	0.85	0.72		

Note: For readability, standardized factor loadings that when rounded to the nearest 10th digit were less than 0.5 were not retained in this table.
[a]These items had reversed scoring.

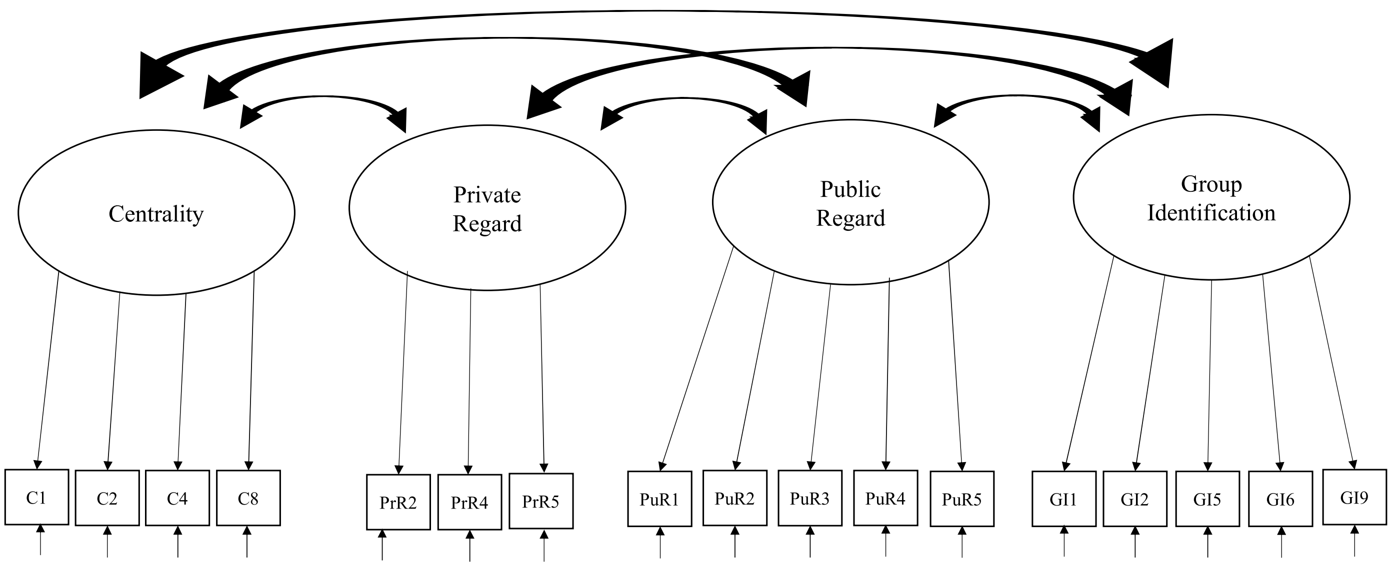

Fig. 2. Measurement model.

0.072 [less than 0.08 indicated a good fit (Hu and Bentler 1999)] also supported the fit of the measurement model.

Data Analysis

To address both research questions, the authors took a SEM approach (Tripathi and Jha 2018) and specified simultaneous regression equations for the four latent constructs using a diagonally weighted least-squares estimation procedure to fit the structural model (Li 2016). In addition to the predictor of gender, demographic characteristics of socioeconomic status (SES), religion, and grade level were included, given that students' engineering identities can be impacted by other traits or circumstances. From the demographic information provided by the survey respondents, these characteristics were selected based upon their lack of correlation and demonstrated heterogeneity within the sample (distributions are given in Table 2), which afforded statistical power. The demographic characteristics were treated as dichotomous variables, with the most frequently occurring level of the original categorical variable coded as category one. This dichotomization was guided by the following question: "Is there a difference in self-identification with each construct between the less-predominant and more-predominant groups?"

Results and Discussion

The regression results of the structural model are in Table 5 and are grouped by the four constructs. Three negative and statistically

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Table 4. Confirmatory factor analysis

Latent construct	Code	Item	Standardized factor loading	Standard error	Item reliability (R^2)	Construct reliability (composite reliability)	Average variance explained
Centrality	C1	Very little to do[a]	0.74	0.035	0.54	0.80	0.52
	C2	Part of self-image	0.86	0.029	0.74		
	C4	Unimportant to my sense[a]	0.74	0.033	0.54		
	C8	Not major factor in social[a]	0.51	0.049	0.26		
Private regard	PrR2	I am happy	0.73	0.041	0.54	0.85	0.65
	PrR4	I often regret[a]	0.84	0.023	0.70		
	PrR5	I am proud	0.84	0.023	0.70		
Public regard	PuR1	Considered good	0.68	0.040	0.46	0.85	0.55
	PuR2	Others respect	0.90	0.023	0.80		
	PuR3	More ineffective[a]	0.59	0.042	0.35		
	PuR4	Not respected by society[a]	0.69	0.043	0.47		
	PuR5	Viewed in positive manner	0.83	0.029	0.68		
Group ID	GI1	I identify	0.83	0.025	0.69	0.88	0.60
	GI2	Glad to belong	0.80	0.031	0.64		
	GI5	Important part on campus	0.70	0.033	0.49		
	GI6	Fit in well	0.76	0.030	0.57		
	GI9	Feel strong ties	0.78	0.025	0.61		
Fit indices							
Standard	χ^2, df	268.5, 114	Robust		χ^2, df	337.4, 114	
	CFI	0.985			CFI	0.951	
	TLI	0.982			TLI	0.942	
	RMSEA	0.066			RMSEA	0.079	
	SRMR	0.072			SRMR	0.072	

Note: Standardized factor loading cut-off is 0.50.
[a]These items had reversed scoring.

significant (p-values less than 0.05) standardized regression coefficients for gender suggest that, on average, the latent constructs of centrality, private regard, and group identification are all meaningfully lower for cis men than for cis women, holding the other demographics constant. Public regard does not differ meaningfully across gender. Furthermore, comparing the magnitudes of the standardized regression coefficients indicates the relative strength of the average effects of the predictors on each construct, with gender consistently having the largest magnitude among the other demographics. From these results, the authors contend that gender has an important role in determining overall engineering identity in the ways of centrality, private regard, and group identification. Despite analyzing demographic characteristics independently of one another, the authors recognize the reality of intersectionality and consider it further in the discussion. In the following sections of the discussion, the authors address each research question in turn, beginning with a broader look at engineering identity before examining construct-specific gender differences.

Upper-Division Cis Women Have Stronger Engineering Identity Compared with That of Cis Men

In response to the first research question, in this data set and under this theoretical framework, the authors find that gender relates to the extent of upper-division students' self-identification with engineering in a statistically significant way. Much of what constitutes engineering identity—namely, centrality, private regard, and group identification—is exhibited more strongly in cis women than in cis men among upper-division undergraduates. Similarly, Meyers et al. (2012) discovered that gender is a significant factor in determining engineering identity. An important difference, however, is that Meyers et al. (2012) observed that male students are more likely to identify themselves as engineers as compared with female students, a trend that was found to hold across all undergraduate years. This difference may be due to their use of a theoretical framework that emphasized behaviors and responsibilities (Meyers et al. 2012) that can be construed as a more task-oriented orientation traditionally ascribed to males (Struch et al. 2002). For example, Meyers et al. (2012) asked if "making a long-term commitment to a company" is necessary to be considered an engineer. The theoretical framework in this study (Chachra et al. 2008) resulted in the survey items being comprised of more "I am" or "I feel" statements as opposed to statements with action verbs (Meyers et al. 2012). The orientation of these types of statements is more expressive, a value typically associated with females (Felder et al. 2002; Struch et al. 2002) and which may have helped to differently elicit responses about identity among cis women in this project.

Chachra et al. (2008) used the engineering identity framework employed within this study, and they found that freshman students' engineering identity is statistically the same for male and female students. The results presented here show that there is a statistical difference in the extent of self-identification with engineering between cis men and cis women among upper-division students. In addition to the inherent differences between Chachra et al. (2008) and the authors' study populations, another explanation for this seeming increase in extent of self-identification from the lower to upper years is the capturing of survey responses from only those cis women with the strongest engineering identities who have persisted in the program. Although this explanation cannot be confirmed without a longitudinal study, this claim is supported by the fact that students' tenacity around self-efficacy and self-confidence, interest, and career goals—factors that relate to engineering identity—assists in determining attrition rates (Besterfield-Sacre et al. 2001; Geisinger and Raman 2013).

Table 5. Regression results from structural model

Latent construct	Item	Standard factor loading	Standard error	Cis man coefficient	Standard error	p-value	Junior coefficient	Standard error	p-value	Upper SES coefficient	Standard error	p-value	Protestant coefficient	Standard error	p-value
Centrality	C1	0.74	0.035	−0.29	0.060	0.00	−0.062	0.063	0.33	0.011	0.060	0.85	−0.15	0.061	0.019
	C2	0.86	0.029												
	C4	0.74	0.032												
	C8	0.51	0.051												
Private regard	PrR2	0.73	0.041	−0.18	0.061	0.0040	−0.16	0.064	0.013	0.064	0.064	0.32	0.041	0.064	0.52
	PrR4	0.85	0.024												
	PrR5	0.85	0.024												
Public regard	PuR1	0.68	0.039	−0.068	0.064	0.29	−0.051	0.064	0.43	0.014	0.065	0.83	−0.037	0.065	0.52
	PuR2	0.90	0.024												
	PuR3	0.60	0.043												
	PuR4	0.69	0.042												
	PuR5	0.83	0.03												
Group ID	GI1	0.84	0.025	−0.24	0.057	0.00	−0.14	0.060	0.062	0.092	0.059	0.12	−0.0060	0.059	0.93
	GI2	0.80	0.031												
	GI5	0.70	0.033												
	GI6	0.76	0.029												
	GI9	0.79	0.025												
Fit indices															
Standard	χ^2, df		290.6, 166		Robust	χ^2, df		385.4, 166							
	CFI		0.986			CFI		0.949							
	TLI		0.989			TLI		0.959							
	RMSEA		0.049			RMSEA		0.065							
	SRMR		0.072			SRMR		0.072							

Note: Coefficient indicates columns of standardized regression coefficients for the four demographic characteristics; p-value ≤0.05 suggests statistical significance. Standardization of regression coefficients permits comparison of strength of association with the constructs across predictors.

Furthermore, Meyers et al. (2012) and Godwin and Lee (2017) observed that engineering identity is stronger in general among upper-division students than among lower-division students. Although this difference has not been consistently observed (Prybutok et al. 2016), this inconsistency may be attributed to the employment of dissimilar theoretical frameworks and definitions of identity. Future qualitative research should continue to explore what students mean by engineering identity, regardless of the framework.

Given that the results in Table 5 also indicate that grade level may affect engineering identity—in this case, with the average senior demonstrating higher private regard than the average junior—future research should explore the intersection of grade level and gender. Despite this study not being longitudinal, nor having the goal of tracking year-specific engineering identity development, the analysis contributes to the body of literature that suggests that the university years influence the development of engineering identity, particularly among cis women, and the overall positioning of students entering the profession.

Engineering Identity Differs across Gender, Except in the Way of Public Regard

In response to the second research question, the results in Table 5 also specify how engineering identity differs across gender. Unlike the other three constituents of engineering identity, the lack of statistical significance of the public regard regression coefficient may suggest that upper-division cis women and cis men do not differ meaningfully in how they believe others view engineers. This result may suggest that the external messages from the engineering programs and broader university of who engineers are and how they are treated [e.g., rigid curricula, noble mission statements, and special t-shirts (Godfrey 2001)] are being interpreted similarly across gender. However, the internalization of these messages appears to be different across gender. Table 5 suggests that cis women more strongly define themselves as engineers (centrality), are surer of their place among fellow engineers (group identification), and feel a greater positivity about engineers (private regard). These results are as expected, given that in general for women in STEM high self-confidence (centrality) and a sense of community (group identification) can help them persist (Settles et al. 2016; Seymour 1997).

Examining existing literature on women in male-dominated environments further assists in understanding some of the potential reasons for this gender-specific internalization of engineering identity. For female engineers, personal and professional identities are often in tension, with gender at the interface of this conflict (Powell et al. 2009; Settles et al. 2016). To gain entry into and acceptance within male-dominated environments, women often must act like men (Bennett et al. 1999). This assimilation, although reinforcing the dominance of the majority (male) group, is arguably a process of professionalization (Powell et al. 2009). During the undergraduate years, Dryburgh (1999) contended that engineering students assimilate into the professional culture by internalizing the professional identity and showing solidarity with other engineers (Faulkner 2006). Those engineering students unable to assimilate and conform to culturally accepted norms and values, just as for women in male-dominated environments at large, leave engineering programs early (Dryburgh 1999). The data here suggest that cis women are more cognizant than cis men of these social pressures to conform to the norms of the professional culture because of their existent deviation from a more pervasive norm. That is, undergraduate engineering cis women may internalize the positive public perspective of engineering (largely shaped by the university) more than cis men as a mechanism for handling disapproval within the engineering community resulting from their violation of social gender norms.

The stronger self-concept of cis women may also be aided by their higher self-clarity. Within the field of psychology, women are generally regarded as having higher self-consciousness (Csank and Conway 2004). A stronger self-concept may arise for undergraduate cis women because of their relatively heightened ability to evaluate the overlap between self and the typical engineer. The survey is effectively designed to engage students in this process of evaluation. This process has been referred to as self-to-prototype matching, with the prototype here being a single engineer that a student believes is representative of the profession. In their study of STEM high school students, Hannover and Kessels (2004) found that the smaller the discrepancy between a student's perception of the prototypical STEM student and a student's self-image, the stronger the affinity for a STEM subject. With a heightened self-awareness and an awareness of the social pressure to conform, cis women may develop a protective level of identification with engineering as a subject, as a profession, and as an identity.

Opportunity: Junior-Year Curriculum

Although acknowledging the limited comparison with the Chachra et al. (2008) study previously mentioned and the recommendation for a longitudinal study, the authors explore the potential intervention opportunity at the transition between the lower- and upper-division grade levels. The contrast between the ungendered engineering identity among lower-division students and gendered identity among upper-division students may indicate an important turning point for engineering students. Introductory coursework for lower-division students seeking degrees in engineering has been associated with limiting diversity (Mervis 2011). Within many public universities, for those engineering students who have survived the introductory courses, junior year marks the beginning of discipline-specific study, which can foster senses of comradery and commitment to engineering (Dryburgh 1999). Focused curricula beginning in junior year could be beneficial for augmenting and sustaining cis women's strong identity through their undergraduate years and into their careers. There is evidence suggesting that context in engineering education curricula affects the development of engineering identity (Jamison et al. 2015) and that context can be differentially important to women (Kilgore et al. 2007). Ongoing research to improve women's retention in engineering programs is seeking to discover the impact of humanitarian engineering context in the engineering classroom [e.g., Cech (2014) has discussed fostering more socially conscious engineers].

Opportunity: Deployment of Survey

As an evocative analogy, McIlwee and Robinson (1992) likened engineering programs to gatekeepers for the profession. They emphasized that faculty members decide the curricula required to learn what engineers are expected to know and also weed out students unfit for the profession. Given the substantial role of engineering faculty in the development of future engineers, the authors recommend that the survey be used benevolently to promote diversity and to help faculty encourage more upper-division students to believe that they are prepared and fit for the profession. The authors recognize the difficulty of finding faculty dedicated to supporting undergraduates, particularly among faculty representing historically excluded identities who can be overburdened by service opportunities. Acknowledging this limitation, as well as the potential danger of discrimination against low-scoring students if these data are shared with ill-intentioned authority, the authors recommend that students have the option of anonymizing their survey prior to it being shared. This survey tool could be utilized to identify students with relatively lower engineering identity for proactive advising and mentorship (Besterfield-Sacre et al. 1997). Students could take the survey anonymously, find out their score, and then decide if they want to seek help if they felt their score reflected that need. In this way, students are provided more protection, privacy, and at the very least, the opportunity for self-reflection if their scores are never shared.

Limitations

The authors recognize the importance of considering the multiple intersecting identities of students (Crenshaw 1989), given that these identities modify one another and shape experience (Li et al. 2009). No social group is homogeneous (Stewart and McDermott 2004), and gender is a multiple and dynamic rather than singular issue. The authors had collected participants' demographic information to help understand the experiences of participants with intersectional identities; however, due to the small sample sizes of students with multiple historically excluded identities, the authors were unable to statistically account for intersectionality in this study. The authors recommend addressing this limitation and extending this paper by collecting additional data on students' experiences via qualitative methods. In addition, conducting a longitudinal study with this survey could help better explore the intersection of grade level and gender for improving understanding of the development of engineering identity during each of the undergraduate years.

Two limitations arising from the study design include sample bias and restrictions inherent to surveys. This study includes 11 large public universities, six of which are land-grant state universities, which is the type of academic institution offering engineering most widely (Riley 2008). It is unclear how university type may affect the engineering identity of cis women in particular (i.e., the direction of the bias), but the authors' ongoing research on engineering identity within a small private institution may help understand the effect. Furthermore, the authors recognize that although the time-efficiency of the survey promotes ease of deployment, it also restricts the amount of information collected. Although this survey takes a snapshot of students' current states, which is useful for targeting more immediate interventions, supplemental qualitative methods would provide a more comprehensive look at students' ongoing (Hannover and Kessels 2004) identity development.

Conclusion

The objective of this paper was to evaluate the role of gender as it relates to the extent of upper-division undergraduate students' self-identification with engineering. Professional persistence is linked to engineering identity, particularly for women, and lack of identification with engineering motivates women to leave the discipline. The long-term health of the construction industry depends upon continued efforts to understand the attrition of historically excluded student groups from engineering programs because these undergraduate years are critical for fostering professional identities and retention in the field. Indeed, for women in the construction industry, earning a college degree has been found to significantly influence their satisfaction in their current employers and their long-term commitment to the industry (Malone and Issa 2013; Naoum et al. 2020).

Beyond Graduation: Women's Transition to and Retention in the Engineering-Construction Industry

With consistency, upper-division cis women more strongly define themselves as engineers, are surer of their place among fellow engineers, and feel a greater positivity about engineers compared with upper-division cis men. By deconstructing engineering identity in this way, the results permit deeper examination of the gender-specific composition of engineering identity and closer linking of retention with identity. Illustratively, the association between a sense of belonging and engineering identity among undergraduate cis women in this study is akin to the link between coworker relationships and retention of women in construction careers (Malone and Issa 2013; Perrenoud et al. 2020). Similarly, for female engineering students, reducing social marginalization among both males and other females has been cited to positively affect achievement and confidence in their ability to succeed in the field (Walton et al. 2015). These senses of belonging may be highly protective components of engineering identity: women may more deeply internalize and fit into engineering to help withstand disapproval due to their violation of gender norms. This deeper internalization of engineering identity, supported by Faulkner (2007), can be extensive and take a good deal of effort for women in the male-dominated industry. The amount of effort undergraduate women need to feel that they fit into engineering may drastically increase upon graduation, and this stark difference may be contributing to poor retention in the profession (Fouad et al. 2011).

Although cis women may have strong engineering identities during the final 2 years of their undergraduate career, the incongruities between themselves and the image of the industry may contribute to their departure from the profession shortly upon their arrival (Amaratunga et al. 2006). For example, the public's regard of the construction industry may be unexpectedly less enthusiastic compared with the perspective conveyed by the university, which may complicate the protective internalization process for cis women. Cis women's identity formation during their undergraduate is undoubtedly influenced by the oft-liberal ideology of the university setting (Linvill and Havice 2011), and the university years may offer a unique period during which students can imagine many definitions of self, a climate which would change their experience of gender norms and pressures surrounding engineering. Strong university-shaped engineering identities, combined with targeted recruitment, may attract women to the industry (Dainty et al. 2000); however, for recently graduated professionals, the amplified daily difficulties of working in a male-dominated environment may be sufficiently disillusioning such that women in the construction industry aged 18–24 express greater interest to leave than women aged 25–54 (Morello et al. 2018).

Internship experience for cis women after their junior year, particularly in firms with women in leadership, might help prepare them for the transition from academia to industry (Godfrey et al. 2010; Menches and Abraham 2007) by providing active personal experience of the culture, exposure to the roles they will encounter as future professionals, and a long-term vision of success for women in the industry. Although further research is needed to confirm engineering identity persistence upon graduation, this study still informs the retention efforts in undergraduate engineering programs for the improvement of the industry's diversity.

Opportunities, in Sum

By using this theoretical framework and comparing with the findings from Chachra et al. (2008), the authors were able to identify an apparent transition between junior and senior years that may mark a gendering of engineering identity. The confinement of the gendered difference in engineering identity to upper-division engineering students may indicate a unique opportunity for targeting resources and introducing context-rich curriculum to sustain the strong identity of the cis women who have persisted in engineering. Within well-resourced and supportive departments, the survey could be deployed as an efficient means of assessing consenting upper-division students' engineering identity to help target interventions to improve retention of excluded identities. Future research could employ the survey to explore the experiences of the students excluded from this analysis, how intersectional statuses influence engineering identity (Tao and McNeely 2019), and how engineering identity evolves postgraduation.

Appendix. Supplementary Tables

Twenty-nine Likert-scale survey items grouped by the four constructs of engineering identity (Chachra et al. 2008)

Abbreviated tag	Full survey item	Code	Construct
Very little to do[a]	Overall, being an engineering student has very little to do with how I feel about myself.[a]	C1	Centrality
Part of self-image	In general, being an engineering student is an important part of my self-image.	C2	
Destiny tied	My destiny is tied to the destiny of other engineering students.	C3	
Unimportant to my sense[a]	Being an engineering student is unimportant to my sense of what kind of person I am.[a]	C4	
Strong sense of belonging	I have a strong sense of belonging to the engineering student community.	C5	
Strong attachment	I have a strong attachment to other engineering students.	C6	
Reflection of who I am	Being an engineering student is an important reflection of who I am.	C7	
Not major factor in social[a]	Being an engineering student is not a major factor in my social relationships.[a]	C8	
Feel good about engineers	I feel good about engineers.	PrR1	Private regard
I am happy	I am happy that I am going to be an engineer.	PrR2	
Major accomplishments	I feel that engineers have made major accomplishments and advancements.	PrR3	
I often regret[a]	I often regret that I am going to become an engineer.[a]	PrR4	
I am proud	I am proud to be an engineer.	PrR5	
Valuable contributions	I feel that the engineering community has made valuable contributions to this society.	PrR6	
Considered good	Overall, engineers are considered good by others.	PuR1	Public regard
Others respect	In general, others respect engineers.	PuR2	
More ineffective[a]	Most people consider engineers, on average, to be more ineffective than other professionals.[a]	PuR3	
Not respected by society[a]	Engineers are not respected by the broader society.[a]	PuR4	
Viewed in positive manner	In general, other professionals view engineers in a positive manner.	PuR5	
Viewed as asset	Society views engineers as an asset.	PuR6	
I identify	I identify with engineering students.	GI1	Group ID
Glad to belong	I am glad to belong to a group of engineering students.	GI2	
Held back[a]	I feel held back by engineering students.[a]	GI3	
Work well together	I think engineering students work well together.	GI4	
Important part on campus	I see myself as an important part of engineering students on campus.	GI5	
Fit in well	I fit in well with the other engineering students.	GI6	
Not important[a]	I consider engineering students to not be important.[a]	GI7	
Feel uneasy[a]	I feel uneasy with other engineering students.[a]	GI8	
Feel strong ties	I feel strong ties to engineering students.	GI9	

[a]These items had reversed scoring.

CFA model-implied correlation matrix

Construct	Centrality	Private regard	Public regard	Group ID
Centrality	1.00	—	—	—
Private regard	0.60	1.00	—	—
Public regard	0.26	0.41	1.00	—
Group ID	0.62	0.67	0.39	1.00

Data Availability Statement

All data, models, and code that support the findings of this study are available from the corresponding author upon reasonable request, including the anonymized survey data, the structural model, and the R code for data cleaning and analysis.

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References

Amaratunga, D., R. Haigh, A. Lee, M. Shanmugam, and G. Elvitigala. 2006. "Construction industry and women: A review of the barriers." In *Proc., 3rd Int. Singapore Clinical Research Institute Research Symp*. Singapore: Singapore Clinical Research Institute.

Appelhans, S., T. De Pree, J. Thompson, J. Aviles, A. Cheville, and D. Riley. 2019. "From 'Leaky pipelines' to 'Diversity of thought': What does 'Diversity' mean in engineering education?" In *Proc., American Society for Engineering Education Annual Conf. and Exposition*. Washington, DC: American Society for Engineering Education.

Aultman, B. 2014. "Cisgender." *TSQ: Transgender Stud. Q.* 1 (1–2): 61–62. https://doi.org/10.1215/23289252-2399614.

Bartholomew, D. J., F. Steele, F. Steele, and I. Moustaki. 2008. *Analysis of multivariate social science data*. Boca Raton, FL: Chapman and Hall/CRC.

Bennett, J. F., M. J. Davidson, and A. W. Galeand. 1999. "Women in construction: A comparative investigation into the expectations and experiences of female and male construction undergraduates and employees." *Women Manage. Rev.* 14 (7): 273–292.

Besterfield-Sacre, M., C. J. Atman, and L. J. Shuman. 1997. "Characteristics of freshman engineering students: Models for determining student attrition in engineering." *J. Eng. Educ.* 86 (2): 139–149. https://doi.org/10.1002/j.2168-9830.1997.tb00277.x.

Besterfield-Sacre, M., M. Moreno, L. J. Shuman, and C. J. Atman. 2001. "Gender and ethnicity differences in freshmen engineering student attitudes: A cross-institutional study." *J. Eng. Educ.* 90 (4): 477–489.

Bollen, K. A. 1989. *Structural equations with latent variables*. New York: Wiley.

Brown, R., S. Condor, A. Mathews, G. Wade, and J. Williams. 1986. "Explaining intergroup differentiation in an industrial organization." *J. Occup. Psychol.* 59 (4): 273–286. https://doi.org/10.1111/j.2044-8325.1986.tb00230.x.

Brunner, M., and H.-M. SÜβ. 2005. "Analyzing the reliability of multidimensional measures: An example from intelligence research." *Educ. Psychol. Meas.* 65 (2): 227–240. https://doi.org/10.1177/0013164404268669.

Carlone, H. B., and A. Johnson. 2007. "Understanding the science experiences of successful women of color: Science identity as an analytic lens." *J. Res. Sci. Teach.: Off. J. Nat. Assoc. Res. Sci. Teach.* 44 (8): 1187–1218. https://doi.org/10.1002/tea.20237.

Cech, E., B. Rubineau, S. Silbey, and C. Seron. 2011. "Professional role confidence and gendered persistence in engineering." *Am. Sociological Rev.* 76 (5): 641–666. https://doi.org/10.1177/0003122411420815.

Cech, E. A. 2014. "Culture of disengagement in engineering education?" *Sci. Technol. Hum. Values* 39 (1): 42–72. https://doi.org/10.1177/0162243913504305.

Chachra, D., D. Kilgore, H. Loshbaugh, J. McCain, and H. Chen. 2008. "Being and becoming: Gender and identity formation of engineering students: Research brief." In *Proc., American Society for Engineering Education Annual Conf.* Washington, DC: American Society for Engineering Education.

Chan, P. W. 2013. "Queer eye on a 'straight' life: Deconstructing masculinities in construction." *Constr. Manage. Econ.* 31 (8): 816–831. https://doi.org/10.1080/01446193.2013.832028.

Crenshaw, K. 1989. *Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics*. 57–80. Chicago: Univ. of Chicago.

Csank, P. A. R., and M. Conway. 2004. "Engaging in self-reflection changes self-concept clarity: On differences between women and men, and low- and high-clarity individuals." *Sex Roles* 50 (7/8): 469–480. https://doi.org/10.1023/B:SERS.0000023067.77649.29.

Dainty, A. R., B. M. Bagilhole, and R. H. Neale. 2000. "A grounded theory of women's career under-achievement in large UK construction companies." *Constr. Manage. Econ.* 18 (2): 239–250. https://doi.org/10.1080/014461900370861.

Dryburgh, H. 1999. "Work hard, play hard: Women and professionalization in engineering—Adapting to the culture." *Gender Soc.* 13 (5): 664–682. https://doi.org/10.1177/089124399013005006.

Faulkner, W. 2006. *Genders in/of engineering*. Swindon, UK: Economic and Social Research Council.

Faulkner, W. 2007. "Nuts and bolts and people' gender-troubled engineering identities." *Social Stud. Sci.* 37 (3): 331–356. https://doi.org/10.1177/0306312706072175.

Felder, R. M., G. N. Felder, and E. J. Dietz. 2002. "The effects of personality type on engineering student performance and attitudes." *J. Eng. Educ.* 91 (1): 3–17. https://doi.org/10.1002/j.2168-9830.2002.tb00667.x.

Fornell, C., and D. F. Larcker. 1981. "Evaluating structural equation models with unobservable variables and measurement error." *J. Marketing Res.* 18 (1): 39–50. https://doi.org/10.1177/002224378101800104.

Fouad, N. A., R. Singh, M. E. Fitzpatrick, and J. P. Liu. 2011. *Stemming the tide: Why women leave engineering.* Final Rep. No. NSF Award 827553. Milwaukee: Univ. of Wisconsin-Milwaukee.

Geisinger, B. N., and D. Raman. 2013. "Why they leave: Understanding student attrition from engineering majors." In *Agricultural and biosystems engineering*, 14. Suwon, Korea: Korean Society for Agricultural Machinery.

Gliem, J. A., and R. R. Gliem. 2003. "Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales." In *Proc., Midwest Research-to-Practice Conf. in Adult, Continuing, and Community.* Indianapolis: Indiana Univ.–Purdue Univ. Indianapolis.

Godfrey, E. 2001. "Defining culture: The way we do things round here." In *Proc., 2001 American Society for Engineering Education Annual Conf. & Exposition*. Washington, DC: American Society for Engineering Education.

Godfrey, E., T. Aubrey, and R. King. 2010. "Who leaves and who stays? Retention and attrition in engineering education." *Eng. Educ.* 5 (2): 26–40. https://doi.org/10.11120/ened.2010.05020026.

Godwin, A., and W. Lee. 2017. "A cross-sectional study of engineering identity during undergraduate education." In *Proc., 2017 American Society for Engineering Education Annual Conf. and Exposition*, 27460. Washington, DC: American Society for Engineering Education.

Godwin, A., and G. Potvin. 2017. "Pushing and pulling Sara: A case study of the contrasting influences of high school and university experiences on engineering agency, identity, and participation." *J. Res. Sci. Teach.* 54 (4): 439–462. https://doi.org/10.1002/tea.21372.

Hannover, B., and U. Kessels. 2004. "Self-to-prototype matching as a strategy for making academic choices. Why high school students do not like math and science." *Learn. Instruction* 14 (1): 51–67. https://doi.org/10.1016/j.learninstruc.2003.10.002.

Hatmaker, D. 2012. "Practicing engineers: Professional identity construction through role configuration." *Eng. Stud.* 4 (2): 121–144. https://doi.org/10.1080/19378629.2012.683793.

Hickey, P. J., and Q. Cui. 2020. "Gender diversity in US construction industry leaders." *J. Manage. Eng.* 36 (5): 04020069. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000838.

Hinkle, S., L. A. Taylor, D. L. Fox-Cardamone, and K. F. Crook. 1989. "Intragroup identification and intergroup differentiation: A multicomponent approach." *Br. J. Social Psychol.* 28 (4): 305–317. https://doi.org/10.1111/j.2044-8309.1989.tb00874.x.

hooks, b. 1981. *Ain't I a woman: Black women and feminism*. Boston: South End Press.

Hu, L., and P. M. Bentler. 1999. "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives." *Struct. Equation Model. Multidiscip. J.* 6 (1): 1–55. https://doi.org/10.1080/10705519909540118.

Jamison, A., N. Mejlgaard, and J. E. Holgaard. 2015. "Fostering hybridity: Teaching about context in engineering education." In *International perspectives on engineering education*, 279–301. Cham, Switzerland: Springer.

Kenny, D. A. 2020. "SEM: Identification (David A. Kenny)." Accessed June 10, 2020. http://davidakenny.net/cm/identify_formal.htm.

Kilgore, D., C. J. Atman, K. Yasuhara, T. J. Barker, and A. Morozov. 2007. "Considering context: A study of first-year engineering students." *J. Eng. Educ.* 96 (4): 321–334. https://doi.org/10.1002/j.2168-9830.2007.tb00942.x.

Li, C.-H. 2016. "Confirmatory factor analysis with ordinal data: Comparing robust maximum likelihood and diagonally weighted least squares." *Behav. Res. Methods* 48 (3): 936–949. https://doi.org/10.3758/s13428-015-0619-7.

Li, Q., H. Swaminathan, and J. Tang. 2009. "Development of a classification system for engineering student characteristics affecting college enrollment and retention." *J. Eng. Educ.* 98 (4): 361–376. https://doi.org/10.1002/j.2168-9830.2009.tb01033.x.

Linvill, D. L., and P. A. Havice. 2011. "Political bias on campus: Understanding the student experience." *J. Coll. Stud. Dev.* 52 (4): 487–496. https://doi.org/10.1353/csd.2011.0056.

MacCallum, R. C., M. W. Browne, and H. M. Sugawara. 1996. "Power analysis and determination of sample size for covariance structure modeling." *Psychol. Methods* 1 (2): 130. https://doi.org/10.1037/1082-989X.1.2.130.

Malone, E. K., and R. R. A. Issa. 2013. "Work-life balance and organizational commitment of women in the US construction industry." *J. Civ. Eng. Educ.* 139 (2): 87–98. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000140.

Manesh, S. N., J. O. Choi, B. K. Shrestha, J. Lim, and P. P. Shrestha. 2020. "Spatial analysis of the gender wage gap in architecture, civil engineering, and construction occupations in the United States." *J. Manage. Eng.* 36 (4): 04020023. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000780.

Matusovich, H. M., R. A. Streveler, and R. L. Miller. 2010. "Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values." *J. Eng. Educ.* 99 (4): 289–303. https://doi.org/10.1002/j.2168-9830.2010.tb01064.x.

McIlwee, J. S., and J. G. Robinson. 1992. *Women in engineering: Gender, power, and workplace culture*. Albany, NY: SUNY Press.

Menches, C. L., and D. M. Abraham. 2007. "Women in construction—Tapping the untapped resource to meet future demands." *J. Constr. Eng. Manage.* 133 (9): 701–707. https://doi.org/10.1061/(ASCE)0733-9364(2007)133:9(701).

Mervis, J. 2011. "Weed-out courses hamper diversity." *Science* 334 (6061): 1333. https://doi.org/10.1126/science.334.6061.1333.

Meyers, K. L., M. W. Ohland, A. L. Pawley, S. E. Silliman, and K. A. Smith. 2012. "Factors relating to engineering identity." *Global J. Eng. Educ.* 14 (1): 119–131.

Morello, A., R. R. Issa, and B. Franz. 2018. "Exploratory study of recruitment and retention of women in the construction industry." *J. Civ. Eng. Educ.* 144 (2): 04018001. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000359.

Morelock, J. R. 2017. "A systematic literature review of engineering identity: Definitions, factors, and interventions affecting development, and means of measurement." *Eur. J. Eng. Educ.* 42 (6): 1240–1262. https://doi.org/10.1080/03043797.2017.1287664.

Naoum, S. G., J. Harris, J. Rizzuto, and C. Egbu. 2020. "Gender in the construction industry: Literature review and comparative survey of men's and women's perceptions in UK construction consultancies." *J. Manage. Eng.* 36 (2): 04019042. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000731.

Osborne, J. W. 2015. "What is rotating in exploratory factor analysis?" *Pract. Assess. Res. Eval.* 20 (2): 8.

Perrenoud, A. J., B. F. Bigelow, and E. M. Perkins. 2020. "Advancing women in construction: Gender differences in attraction and retention factors with managers in the electrical construction industry." *J. Manage. Eng.* 36 (5): 04020043. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000808.

Petray, T., T. Doyle, E. Howard, R. Morgan, and R. Harrison. 2019. "Re-engineering the 'leaky pipeline' metaphor: Diversifying the pool by teaching STEM 'by stealth'." *Int. J. Gender Sci. Technol.* 11 (1): 10–29.

Pierrakos, O., T. K. Beam, J. Constantz, A. Johri, and R. Anderson. 2009. "On the development of a professional identity: Engineering persisters vs engineering switchers." In *Proc., 2009 39th IEEE Frontiers in Education Conf.*, 1–6. New York: IEEE.

Powell, A., B. Bagilhole, and A. Dainty. 2009. "How women engineers do and undo gender: Consequences for gender equality." *Gender Work Organ.* 16 (4): 411–428. https://doi.org/10.1111/j.1468-0432.2008.00406.x.

Powell, A., and K. J. C. Sang. 2013. "Equality, diversity and inclusion in the construction industry." *Constr. Manage. Econ.* 31 (8): 795–801. https://doi.org/10.1080/01446193.2013.837263.

Prybutok, A., A. Patrick, M. Borrego, C. C. Seepersad, and M. Kirisits. 2016. "Cross-sectional survey study of undergraduate engineering identity." In *Proc., 2016 American Society for Engineering Education Annual Conf. and Exposition*, 26610. Washington, DC: American Society for Engineering Education.

Riley, D. 2008. "Engineering and social justice." *Synth. Lect. Eng. Technol. Soc.* 3 (1): 1–152. https://doi.org/10.2200/S00117ED1V01Y200805ETS007.

Sass, D. A. 2011. "Testing measurement invariance and comparing latent factor means within a confirmatory factor analysis framework." *J. Psychoeducational Assess.* 29 (4): 347–363. https://doi.org/10.1177/0734282911406661.

Sellers, R. M., S. A. J. Rowley, T. M. Chavous, J. N. Shelton, and M. A. Smith. 1997. "Multidimensional inventory of black identity: A preliminary investigation of reliability and constuct validity." *J. Personality Social Psychol.* 73 (4): 805–815. https://doi.org/10.1037/0022-3514.73.4.805.

Settles, I. H., R. C. O'Connor, and S. C. Yap. 2016. "Climate perceptions and identity interference among undergraduate women in STEM: The protective role of gender identity." *Psychol. Women Q.* 40 (4): 488–503. https://doi.org/10.1177/0361684316655806.

Seymour, E. 1997. *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Sheppard, S., A. Antonio, S. Brunhaver, and S. Gilmartin. 2015. "Studying the career pathways of engineers: An illustration with two data sets." In *Cambridge handbook of engineering education research*, 283–310. Cambridge, UK: Cambridge University Press.

Shi, Y. 2018. "The puzzle of missing female engineers: Academic preparation, ability beliefs, and preferences." *Econ. Educ. Rev.* 64 (Jun): 129–143. https://doi.org/10.1016/j.econedurev.2018.04.005.

Shrestha, B. K., J. O. Choi, P. P. Shrestha, J. Lim, and S. Nikkhah Manesh. 2020. "Employment and wage distribution investigation in the construction industry by gender." *J. Manage. Eng.* 36 (4): 06020001. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000778.

Skinner, D., J. Valsiner, and D. Holland. 2001. "Discerning the dialogical self: A theoretical and methodological examination of a Nepali adolescent's narrative." *Forum Qual. Sozialforschung/Forum: Qual. Soc. Res.* 2 (3).

Spelman, E. V. 1988. *Inessential woman: Problems of exclusion in feminist thought*. Boston: Beacon Press.

Stevens, R., K. O'Connor, and L. Garrison. 2005. "Engineering student identities in the navigation of the undergraduate curriculum." In *Proc., American Society for Engineering Education Annual Conf.*, 1–8. Reston, VA: ASCE.

Stewart, A. J., and C. McDermott. 2004. "Gender in psychology." *Annu. Rev. Psychol.* 55 (1): 519–544. https://doi.org/10.1146/annurev.psych.55.090902.141537.

Strenta, A. C., R. Elliott, R. Adair, M. Matier, and J. Scott. 1994. "Choosing and leaving science in highly selective institutions." *Res. Higher Educ.* 35 (5): 513–547. https://doi.org/10.1007/BF02497086.

Struch, N., S. H. Schwartz, and W. A. Van Der Kloot. 2002. "Meanings of basic values for women and men: A cross-cultural analysis." *Personality Social Psychol. Bull.* 28 (1): 16–28. https://doi.org/10.1177/0146167202281002.

Sunindijo, R. Y., and I. Kamardeen. 2017. "Work stress is a threat to gender diversity in the construction industry." *J. Constr. Eng. Manage.* 143 (10): 04017073. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001387.

Tao, Y., and C. L. McNeely. 2019. "Gender and race intersectional effects in the US engineering workforce: Who stays? Who leaves?" *Int. J. Gender Sci. Technol.* 11 (1): 181–202.

Tate, E. D., and M. C. Linn. 2005. "How does identity shape the experiences of women of color engineering students?" *J. Sci. Educ. Technol.* 14 (5–6): 483–493. https://doi.org/10.1007/s10956-005-0223-1.

Thompson, B. 2004. *Exploratory and confirmatory factor analysis: Understanding concepts and applications*, 10694. Washington, DC: American Psychological Association.

Tonso, K. L. 2007. *On the outskirts of engineering: Learning identity, gender, and power via engineering practice*. Leiden, Netherlands: Brill Sense.

Tripathi, K. K., and K. N. Jha. 2018. "Determining success factors for a construction organization: A structural equation modeling approach." *J. Manage. Eng.* 34 (1): 04017050. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000569.

US Bureau of Labor Statistics. 2019. "Employed persons by detailed industry, sex, race, and Hispanic or Latino ethnicity." Accessed February 13, 2020. https://www.bls.gov/cps/cpsaat18.htm.

Walden, S., D. Trytten, R. Shehab, and C. Foor. 2018. *Critiquing the 'underrepresented minorities' label*. Atlanta: American Society for Engineering Education.

Walton, G. M., C. Logel, J. M. Peach, S. J. Spencer, and M. P. Zanna. 2015. "Two brief interventions to mitigate a 'chilly climate' transform women's experience, relationships, and achievement in engineering." *J. Educ. Psychol.* 107 (2): 468. https://doi.org/10.1037/a0037461.

Watson, K., and J. Froyd. 2007. "Diversifying the US engineering workforce: A new model." *J. Eng. Educ.* 96 (1): 19–32. https://doi.org/10.1002/j.2168-9830.2007.tb00912.x.