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Engineering Role Identity Fosters Grit Differently for Women First- and Continuing-Generation College Students*

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This study examined two distinct groups of women in engineering (i.e., first-generation and continuing-generation college students) to understand how the engineering role identity constructs of interest, recognition, and performance/competence fostered grit–perseverance of effort and grit–consistency of interest. A survey was administered to first-year engineering students at four institutions across the United States. The sample of women was $n = 675$, from which $n = 144$ were identified as first-generation college students and $n = 531$ were identified as continuing-generation college students. Using existing instruments, two structural equation models were created to test the relationships between engineering role identity constructs and grit. The model of first-generation college students had high interest in engineering, which, in turn, was predictive of their grit–consistency of interest, while their beliefs about performing well and understanding engineering content was predictive of their grit–perseverance of effort. In the model of continuing-generation college students, being recognized as someone that can do engineering was predictive of grit–perseverance of effort while seeing oneself as an engineer was predictive of their grit–consistency of interest. The results of this work highlight different aspects of identity that may foster grit for women in engineering depending upon their parents' level of education.

Keywords: first-generation college students; women; engineering role identity; grit; structural equation modeling

1. Introduction

In the United States, women outnumber men in terms of total college enrollment [1, 2]. However, women have not achieved parity in graduating with engineering degrees. The low participation of women in engineering (20.9%, [3]) is not unique to the United States; it is also seen in several other countries. For example, in 2015 women engineers in Canada made up 20.1% [4], whereas women engineers make up less than 10% in the United Kingdom, the lowest percentage in Europe [5]. Additionally, in the U.S., women who identify as Latina, Black/African American, Native American, or Alaskan Natives have been earning significantly lower numbers of degrees in engineering compared to white women [6].

Women's experiences in engineering vary based on several factors, including race/ethnicity, socioeconomic status, and parental level of education (i.e., first-generation college students). This point is best represented in a study by Foor and colleagues [7], who offer a powerful insight of Inez, a first-generation college student (i.e., neither parent has obtained bachelor's degree). Inez, recalled being ill-advised by university personnel in a way that deterred her from seeking out an internship opportunity, she said, "I . . . have not done an internship . . . The teachers then think that I don't know anything. I haven't had a chance to be involved in something like that [internship] . . ." [7, p. 110]. Another student who was identified as a continuing-generation college student (i.e., one or more parent obtained a bachelor's degree or higher) used family connections to acquire an internship [7].

Another study of engineering students who were low-income and first-generation college students highlighted the unique experiences they faced entering an engineering pathway and their persistent character or grit in pursuing an engineering degree [8]. One participant, Bianca, stated, "Nobody told me I had the potential to do science . . . but I believe that I have potential" [8, p. 276]. Bianca further declared that a lot of underrepresented students are not properly guided or informed of their options during and after high school. Bianca also shared that the lack of seeing other people like her prompted her to "sometimes feel like I don't belong . . . I feel like I'm alone; I decided to do chemical engineering . . . pero estoy en este camino [I'm in this journey] by myself" [8, p. 277]. Similarly, Carmen was a student who initially did not believe going to college was an option; nevertheless, upon enrolling in the electrical engineering program she was emblematic of the persistence that was needed to become successful, stating, "I'm very

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committed . . . I never said I'm not going to finish [electrical engineering] . . . I think those who do change their major, I think they're weak or not committed ... commit, just do it, nothing comes easy nobody gives you anything for free, you need to work for it" (Carmen) [8, p. 275]. All first-generation college students in these studies faced challenges, yet persevered towards completing their engineering and science degrees [7, 8].

Inez, Bianca, and Carmen described an ability and desire to persevere in engineering despite many barriers and an often unwelcoming environment. In the literature this characteristic is conceptualized as grit [9, 10]. Grit has been defined by Duckworth as "perseverance and passion for long-term goals" [9, p. 1097]. Grit has been measured using two constructs: perseverance of effort and consistency of interest [20]. Perseverance of effort captures an individual's ability to continue to engage in a goal despite adversity (e.g., setbacks, barriers, etc.). Additionally, grit consists of an individual's consistency of interest or a deep personal motivation to engage in a goal rather than a sustained effort because of a fear of change, need to please others, or a lack of awareness of other goal options. Throughout the text, we refer to the two constructs as grit–perseverance of effort and grit–consistency of interest.

To understand how grit develops for women, we examined how engineering role identity may influence grit for first-generation college students in comparison to their peers. Engineering role identity has been measured using three constructs: interest, performance/competence beliefs, and recognition beliefs [11, 12]. Based on the prior literature (described in more detail below) and the stories described above, we hypothesize that first-generation college students develop grit–perseverance of effort and grit–consistency of interest differently than their continuing-generation college student peers.

Engineering culture in general has been described as unwelcoming or even "chilly" for women [13]. For women first-generation college students, this effect may be compounded as this group is largely from underrepresented racial/ethnic groups [14], lower socioeconomic status [14, 15], and often are viewed as "culturally mismatched," "remedial," or underprepared" [16–18]. The structures of the educational environment can shape how identity [19] and, in turn, grit may be formed for women from households with different levels of parental education.

1.1 Identity as the precursor to grit–perseverance of effort and grit–consistency of interest

Grit enables individuals to sustain effort and stick to their goals [20]. We believe that students demonstrate grit in pursuing a goal (e.g., pursuing an engineering degree) when they are intrinsically motivated, believe in their capabilities, and are in an environment that recognizes their efforts. Renninger et al. [21] found that learners who are interested in specific tasks "are likely to be able to self-regulate and persist to complete tasks even when they are challenged, whereas learners with little interest typically have difficulty engaging and continuing to work with tasks" [p. 2]. This trend echoes the statement by the U.S. Department of Education that "persevering in the face of challenges or setbacks to accomplish goals that are . . . unimportant to the student . . . can have detrimental impact on students' learning and psychological well-being" [22, p. 93]. Thus, we posit that students need to first demonstrate a level of interest in a task, school subject, or goal to develop a gritty mindset (specifically, grit–consistency of interest). Additionally, students' beliefs in their abilities to understand and perform well on a task (e.g., self-efficacy) is an important factor in persevering in the face of difficulties, which is considered to be grit–perseverance of effort. Bandura posited that through self-efficacy beliefs, "people choose which challenges to undertake, how much effort to invest in the pursuits and how long to persevere in the face of difficulties" [23, p. 28]. Finally, students beliefs that others see them as the kind of people that can do engineering (e.g., recognition beliefs) have been found to be important, for women in choosing and persisting in engineering careers [24, 25]. However, these prior studies did not distinguish between first-generation and continuing-generation college students. A study by Verdín et al. [26] specifically focused on first-generation college students found that women were less likely than men to be recognized by peers, instructors, and parents as a physics person [26], an important precursor to engineering identity [26] and engineering career path [24]. Based on prior work, we believe an underlying difference exists between women who are first-generation and continuing-generation college students and test those differences for engineering identity and grit in this study.

Additionally, as research on grit continues to progress, there is both praise in how grit surpasses metrics of intelligence and aptitude towards assessing student success [9, 20] and fear that grit privileges certain types of students (e.g., high-income or students in majority groups) [27, 28]. However, understanding how grit is fostered through engineering identity building constructs (i.e., interest, performance/competence beliefs, and recognition beliefs) is a more equitable way of understanding how grit is developed. Our approach considers the different ways women in engineering (i.e., first-generation and continuing-generation college students) develop as engineers and develop grit within the context of engineering. In this work, we seek to better understand how engineering environments may provide different experiences and opportunities for women from different backgrounds. Therefore, this study seeks to understand if self-reported measures of engineering identity foster grit for first-generation and continuing-generation college students.

2. Theoretical framing

2.1 Grit

Grit has garnered attention beyond U.S.-based psychological research into science, technology, engineering, and mathematics (STEM) education (see [29–32]), and has also crossed into transnational spaces of educational reforms [33, 34].

Grit has been conceptualized as distinct from other personality traits. Although grit may resemble the Big Five personality trait of conscientiousness in terms of achievement, grit differs in its emphasis on long-term stamina, emphasizing the role of effort and interest in the long run [9]. Studies using grit found that grit "accounted for significant incremental variance in success outcomes over and beyond IQ" and the Big Five personality trait conscientiousness [9, p. 1098], [20]. A study asking participants to complete three different problem-solving tasks found that when compared to participants with lower self-reported measures of grit, grittier individuals were more likely to increase effort when they were struggling with a problem-solving task, and "more likely to stay and keep fighting a losing battle when they could quit" [36, p. 20]. Additionally, when grittier participants received feedback that they were failing, they were more likely to persist than their less gritty peers [36]. In a study of first-year engineering students, grit–perseverance of effort was found to be a significant predictor of one- and two-year engineering retention, even after controlling for mathematics grades [29].

Studies on grit are still emerging. While most studies using grit focus on how grit is related to achievement or retention [29, 32, 37], few studies have focused on how students develop grit. This lack of empirical evidence on grit development can lead researchers and practitioners to believe that grit is an innate trait that students either have or do not have. For this work we address this gap in the literature by examining context specific factors of engineering role identity (i.e., interest, recognition beliefs and performance/competence beliefs, and a single measure of engineering identity) that may influence development of grit–perseverance of effort and grit–consistency of interest.

2.2 Authoring an engineering identity through performance/competence beliefs, interest, and recognition beliefs

Becoming a member in a community of practice fosters identity development in that discipline and involves taking on roles, behaviors, and attitudes that are defined and shared within such a community [38, 39]. Developing an identity within an engineering discipline is important for supporting students' future commitments to the field. Disciplinary role identity (in this case, as an engineer), is defined as "being recognized as a certain 'kind of person,' in a given context," [40, p. 99] that is, an individual's social performance rather than their unique being [40, 41].

The authoring of one's social performance within the engineering context is done through three interrelated dimensions, performance/competence, interest, and recognition. Performance/competence is understood as students' self-reported beliefs about performing well using "relevant scientific practices (e.g., ways of talking and using tools) and being able to understand the material presented to them [42, p. 1191]. Performance/competence beliefs are combined; several prior quantitative studies found that undergraduate students could not distinguish between their beliefs about content knowledge (competence) and beliefs about their ability to do well (performance) in a given context [12, 24, 43]. However, one's beliefs about understanding and efficacy in performing well in engineering is not enough. Authoring an identity as an engineer also requires internal and external recognition [42, 43]. Gee [40] noted that one's identity becomes an identity when "they are recognized by [themselves] or others" [p. 102] in a particular context. Thus, recognition is realized through interaction, or performance; that is, a student cannot be recognized as a certain kind of person unless she makes visible (performs) her competence in particular domains [42].

Prior to the implementation of the *Next Generation Science Standards* (NGSS), scholars Moore, Tank, Glancy, and Kerston [44] found that a "small percentage of engineering [was] explicitly present (5%) in the science standards documents across all 50 states" [p. 311]. Currently, engineering content has been incorporated into the elementary and secondary school curricula for 36% of the student population in the United States. [45]; thus, students' interest in engineering is crucial. Being interested in engineering plays a key role in the framing of role identity and involves a personal desire for learning and understanding in each context [46].

Prior work has established that first-generation college students, demonstrate greater interest in engineering and greater interests in pursuing a career in engineering when compared to continuing-generation college students [47, 48]. Therefore, we hypothesized the same greater self-reported measures of interest will hold true for women who are first-generation college students in this study. Additionally, we hypothesized that women who are continuing-generation college students would report greater instances of being recognized as the type of people that can do engineering, based on results of our prior findings. Prior work found that continuing-generation college students were more likely to be recognized as a physics person [47]. Having a physics identity (which encompasses being recognized by others as a physics person) is predictive of choosing an engineering major [24, 30, 47, 49]. Lastly, rejecting the notion that grit is an innate trait (i.e., some people have it while others do not), we examine how grit–perseverance of effort and grit–consistency of interest can be further fostered through engineering identity constructs.

3. Hypothesis

Our prior work has established a relationship that engineering identity fosters grit (perseverance of effort and consistency of interest) for first-generation college students (both men and women) [31], as shown in Fig. 1. In our model of engineering identity, performance/competence beliefs are fully mediated by students' interest and recognition beliefs, which is consistent with prior work modeling mathematics, physics, and engineering identities [31, 46, 50]. However, prior work has also shown that there are important differences between men and women and first-generation college students using these subject-related role identity measures [26, 47, 51]. These differences have been explored separately but not together, therefore, we hypothesize that engineering role identity may influence grit differently for women who are first- and continuing-generation college students. For these reasons, we explore women's engineering identity and grit in two separate models to test the following hypotheses:

H1. In both models, interest and recognition beliefs will mediate performance/competence onto women's beliefs of seeing themselves as engineers.
H2. The first-generation college student model will have higher levels of self-reported interest in engineering, while the continuing-generation college student model will have moderate levels of self-reported interest in engineering.
H3. The continuing-generation college student model will have higher self-reported levels of being recognized as an engineer, while the first-generation college student model will have moderate self-reported levels of being recognized as an engineer.
H4. For both models, beliefs about performing well and understanding engineering will be significant for grit–perseverance of effort.
H5. Interest in engineering will be significant for grit–consistency of interest in both models.
H6. Seeing oneself as an engineer will have a direct effect on consistency of interest and grit–perseverance of effort for both models.

4. Methods

4.1 Sample

A paper-and-pencil survey was administered to first-semester, first-year engineering students in the Fall of 2015. We obtained a sample size of $n = 2{,}916$ students. The study was part of a larger mixed methods project [52, 53] that was administered at three land-grant institutions and one Hispanic-

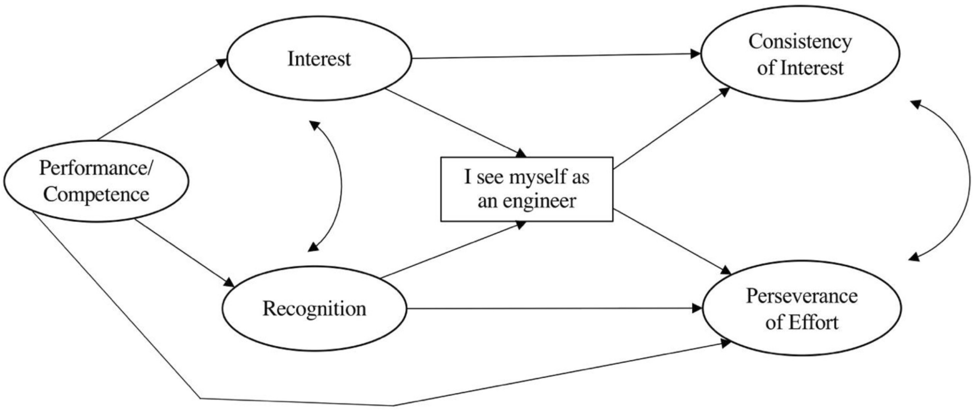

Fig. 1. Proposed structural equation model of the relationship between the engineering identity building constructs of interest, recognition, and performance/competence onto two first-order latent variables of grit–consistency of interest and grit–perseverance of effort.

Serving Institution in the United States in their respective introductory to engineering courses.

In this study, we used a subset of the student population, women. Of the overall 2,916 students who completed the survey, 77% (n_M = 2,241) identified as men, 23% (n_W = 675) identified as women, whereas 7% (n_D = 213) reported a gender different from female, male, or did not wish to report. Students were free to mark all genders that were part of their identity. Students who identified as women, irrespective of simultaneously identifying with another gender, were retained for the analysis of this study. Students were recorded as first-generation college students if they reported their parents' level of education was "less than a high school diploma," "high school diploma/ GED," or "some college or associate/trade degree." Students who reported having one or more parent who completed a "bachelor's degree" or "master's degree or higher" were classified as continuing-generation college students. In our sample of women, 144 were identified as first-generation college students and 531 were identified as continuing-generation college students. To account for missing data, for the attitudinal variables, multiple imputation was implemented using the Amelia II program for missing data [54].

4.2 Grouping used in the analysis

This study focuses exclusively on women (n_W = 675) in two distinct groups: first-generation college students (n_{FGCS} =144) and continuing-generation college students (n_{CGCS} = 531). Since this study focuses entirely on the sampled population of women, throughout our results and discussion we refer to these women based on their grouping (i.e., first-generation college students or continuing-generation college students). Demographic information of each grouping can be found in Table 1.

4.3 Survey questionnaires

The latent variables used in this study have shown strong validity evidence in previous work (i.e., engineering identity measures [12], and grit [20]). All items were assessed using a 7-point anchored numeric scale ranging from "0-Strongly Disagree" to "6-Strongly Agree." To measure students' engineering identity constructs (i.e., interest, recognition belief, performance/competence beliefs) students were asked "To what extent do you agree or disagree with the following statements," followed by three interest, three recognition, and four performance/competence items. A single item was used to capture students' overall engineering identity; "I see myself as an engineer." The measures of grit–perseverance of effort and grit–consistency of interest were captured by the following statement, "How closely do the following describe you?" Grit–perseverance of effort is comprised of three items and grit–consistency of interest consists of two items. The survey instrument with the established scales is published in our prior work [53].

4.4 Data analysis

Two separate structural equation models (SEM) were used to test the hypotheses that engineering identity constructs serve as mediators for students measures of perseverance of effort and consistency of interest. Structural equation modeling allows the researcher to model the quality of the measurements of the latent constructs as well as the relationships between them. This approach is more robust when using indirect (latent variable) measures because it models measurement error separately from model [59] error. Data were analyzed in four steps: (1) normality assumptions were examined, (2) confirmatory factor analysis was conducted, (3) measurement invariance was checked, and (4) two separate structural model fits were examined. A brief summary of the four steps can be found in Fig. 2 and are discussed in detailed in the paragraphs that follow.

First, data was screened to verify assumptions of univariate and multivariate normality through skewness, kurtosis, and Mardia's Test. For univariate normality, the cut-off values we used were based on recommendations for large sample sizes $n > 300$

Table 1. Demographic information of the women analyzed in this study by group

	First-Generation College Students	**Continuing-Generation College Student**
Asian	18	89
Black or African American	20	26
Latina, Hispanic, or Spanish origin	43	45
Middle Eastern or Native African	1	7
Native American or Alaska Native	10	3
Native Hawaiian or another Pacific Islander	3	1
White	76	380
Another race/ethnicity not listed above	3	8
*Total sample of women in each group	144	531

Note. * Students were allowed to choose any and all race/ethnicities they identified as.

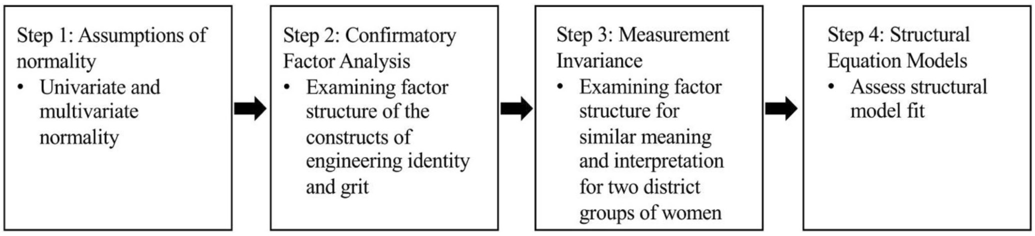

Fig. 2. Summary of the sequential steps used to conduct a structural equation modeling analysis.

[55]; skewness should range between –2 to 2 and kurtosis should range from –7 to 7 [55, 56]. To examine deviation from multivariate normality, Mardia's Test was used under the MVN package version 5.6 in R [57]. Construct reliability was examined using Cronbach's alpha, for both groups of women. For the first-generation college student group coefficients ranged within 0.72 to 0.94. For the continuing-generation college student group coefficients ranged within 0.70 to 0.92. All Cronbach alpha levels indicated that as a set, the items are closely related [58].

Second, a confirmatory factor analysis (CFA) was conducted for the engineering identity constructs of interest, recognition beliefs, and performance/competence beliefs and perseverance of effort and consistency of interest using model fit indices suggested by Kline [59] and Brown [60]. Fit indices used to assess the CFA include: chi-square goodness of fit, comparative fit index (CFI; acceptable values above 0.9 [61]), Tucker Lewis index (TLI; acceptable values above 0.9 [61]), root mean square error of approximation (RMSEA; values less than 0.08 indicate moderate fit [62]), and standardized root mean square residual (SRMR; acceptable value is less than 1, where 0.0 would indicate perfect fit [60, 63]). The chi-square goodness of fit test is sensitive to large sample sizes ($n > 200$), nevertheless it is commonly reported in SEM analysis [60, 64].

After confirming the constructs had acceptable model fit, we tested how well the items measured the underlying latent variables using confirmatory factor analysis. As a part of this confirmatory factor analysis, we also examined if the items functioned differently between the two groups of women (i.e., first-generation and continuing-generation college students). This process is called measurement invariance testing. The measurement invariance tests assess for configural (equal loadings patterns), metric (equal factor loading), scalar (equal loadings and intercepts), and strict (equal loadings, intercepts, and means) invariance in hierarchical order. Each type of invariance test "represents increasingly restrictive hypotheses and, each successive hypothesis requires more evidence than the preceding hypothesis" [59, p. 396]. This step ensured that we were measuring the same latent constructs for the two different groups.

After confirming measurement invariance, the final step involved, structural model fit which is examined using the same fit indices described above. The structural model involves simultaneous regressions of latent variables onto one another. It allows the influence of different latent variables to be tested at the same time within the same analysis. All analyses were conducted using the R statistical language version 3.4.0 [65]. The confirmatory factor analysis and structural equation modeling were conducted using the lavaan package [66].

5. Results

5.1 Assumptions of normality

Univariate normality revealed acceptable ranges of skewness (values within ± 2.0) and kurtosis (values within ± 7.0), for both datasets. Mardia's test for multivariate normality revealed that both datasets were not multivariate normal, therefore, a robust maximum likelihood (MLM) estimator was used to correct for non-normality. MLM corrects for both the model chi-square and the standard errors of the parameter estimates for deviations from a normal distribution [60, 67]. Our results yield a significant Satorra-Bentler chi-square goodness of fit for all latent constructs; however, it is known that this test is particularly sensitive for large sample sizes and that RMSEA is a better and less sensitive measure of model fit [62].

5.2 Confirmatory factor analysis summary

Independent confirmatory factor analyses were conducted for the latent constructs of engineering identity and grit for each group. For first-generation college students the Satorra-Bentler adjusted chi-square test for goodness of fit, for the engineering identity and grit constructs, was $\chi^2_{SB} = 108.33$, $df = 80$, $p < 0.02$. The remaining fit indices were CFI of 0.97, TLI of 0.96, RMSEA of 0.05 with 90% confidence interval of [0.03, 0.07], and an SRMR of 0.05.

The model summary for the constructs of engineering identity and grit, for the continuing-generation college student group, had a Satorra-Bentler adjusted chi-square test for goodness of fit of $\chi^2_{SB} = 215.20$, $df = 80$, $p < 0.001$. The fit indexes were CFI of 0.96, TLI of 0.95, RMSEA of 0.06 with 90% confidence interval of [0.05, 0.07], and an SRMR of 0.04. Overall, the fit indexes for both models suggest good overall model fit.

Tables 2 and 3 include standardized factor loadings, standard error, item reliability construct reliability (α), and average variance extracted for each group of women. All standardized factor loadings were above the 0.45 minimum. Item reliability was evaluated using the multiple squared correlation, and variables for the engineering identity constructs and grit constructs were above 0.50 indicating the items measure above 50% of the variance. The construct reliability were between 0.72 to 0.94, all above 0.70, indicating good construct reliability [58]. The amount of variance captured by each construct was greater in relation to the amount of variance due to measurement error, i.e., variance was above 0.50 [68].

5.3 Testing measurement invariance

After establishing acceptable model fit, a measurement invariance test was conducted using our confirmatory factor analysis framework, to determine if women in the first-generation and continuing generation college student groups conceptualized the constructs of engineering identity and grit similarly. For a comprehensive discussion of measurement invariance see [59, 60, 69] and for an example of measurement invariance with a similar population see [51]. All models in the measurement invariance tests (i.e., configural, metric, scalar, and strict) were found to be invariant across groups—see Table 4. With the understanding that there was measurement invariance across the two groups; following, two independent structural equation models were run.

5.4 Two structural model summaries

Two independent structural equation models were run, one for first-generation college students and another for continuing-generation college students. Non-significant paths for each model were removed to obtain the most parsimonious models. The resulting models are shown in Fig. 3 and a summary of the results can also be found in Table 5. The Satorra-Bentler adjusted chi-square test for goodness of fit for the model of first-generation college students, was $\chi^2_{SB} = 130.32$, $df = 97$, $p < 0.01$. The fit indexes were CFI of 0.97, TLI of 0.97, RMSEA of 0.05 with 90% confidence interval of [0.027, 0.067], and an SRMR of 0.06. Overall, the fit indexes suggest good overall model fit.

Similarly, the Satorra-Bentler adjusted chi-square test for goodness of fit was used for continu-

Table 2. Confirmatory Factor Analysis Estimates and Fit Indices for the Model of Women First-Generation College Students in Engineering

Latent variables Indicators	Std. factor loadings	*SE*	Item reliability (R^2)	Construct reliability (α)	Average variance extracted
Interest				0.90	0.80
I am interested in learning more about engineering.	0.80***	0.07	0.63		
I enjoy learning engineering.	0.99***	0.07	0.97		
I find fulfillment in doing engineering.	0.87***	0.11	0.76		
Recognition Beliefs				0.87	0.69
My parents see me as an engineer.	0.76***	0.15	0.57		
My instructors see me as an engineer.	0.87***	0.12	0.73		
My peers see me as an engineer.	0.89***	0.13	0.78		
Performance/Competence Beliefs				0.94	0.79
I am confident that I can understand engineering in class.	0.90***	0.10	0.82		
I am confident that I can understand engineering outside of class.	0.93***	0.09	0.86		
I can do well on exams in engineering.	0.90***	0.09	0.81		
I understand concepts I have studied in engineering.	0.82***	0.08	0.67		
Grit Persistence of Effort				0.78	0.56
I am a hard worker.	0.77***	0.08	0.59		
I finish whatever I begin.	0.72***	0.11	0.52		
I am diligent.	0.87***	0.12	0.60		
Grit Consistency of Interest				0.72	0.57
I have been obsessed with a certain idea about a project for a short time but later lost interest.	0.70***	0.21	0.49		
I often set a goal but later choose to pursue a different one.	0.81***	0.19	0.66		

Note. *** $p < 0.001$, acceptable values of item reliability (R^2) > 0.50, construct reliability > 0.70, and average variance extracted > 0.50.

Table 3. Confirmatory Factor Analysis Estimates and Fit Indices for the Model of Women Continuing-Generation College Students in Engineering

Latent variables Indicators	Std. factor loadings	*SE*	Item reliability (R^2)	Construct reliability (α)	Average variance extracted
Interest				0.88	0.75
I am interested in learning more about engineering.	0.76***	0.04	0.59		
I enjoy learning engineering.	0.94***	0.03	0.87		
I find fulfillment in doing engineering.	0.87***	0.03	0.76		
Recognition Beliefs				0.81	0.62
My parents see me as an engineer.	0.68***	0.06	0.51		
My instructors see me as an engineer.	0.81***	0.05	0.64		
My peers see me as an engineer.	0.82***	0.05	0.63		
Performance/Competence Beliefs				0.90	0.75
I am confident that I can understand engineering in class.	0.90***	0.05	0.76		
I am confident that I can understand engineering outside of class.	0.92***	0.04	0.79		
I can do well on exams in engineering.	0.86***	0.04	0.78		
I understand concepts I have studied in engineering.	0.78***	0.05	0.65		
Grit Persistence of Effort				0.70	0.51
I am a hard worker.	0.62***	0.05	0.37		
I finish whatever I begin.	0.61***	0.07	0.38		
I am diligent.	0.83***	0.06	0.68		
Grit Consistency of Interest				0.78	0.51
I have been obsessed with a certain idea about a project for a short time but later lost interest.	0.71***	0.07	0.52		
I often set a goal but later choose to pursue a different one.	0.84***	0.07	0.68		

Note. *** $p < 0.001$, acceptable values of item reliability (R^2) > 0.50, construct reliability > 0.70, and average variance extracted > 0.50.

Table 4. Summary of measurement invariance for engineering identity and grit constructs between women first-generation college students and continuing-generation college students

Measurement Invariance Models	χ^2_{SB} (*df*)	CFI	RMSEA (90% CI)	$\Delta \chi^2_{SB}$ (Δdf)	ΔP	ΔCFI	ΔRMSEA
Model 1: Configural Invariance	4670.23 (188)	0.96	0.06 (0.06–0.07)	–	–	–	–
Model 2: Metric Invariance (loadings)	4740.08 (199)	0.96	0.06 (0.06–0.07)	60.85 (11)	0.81	0.001	0.002
Model 3: Scalar Invariance (intercepts)	4890.96 (210)	0.96	0.06 (0.06–0.07)	150.88 (11)	0.15	0.001	0.001
Model 4: Strict Invariance (means)	4980.92 (215)	0.95	0.06 (0.06–0.07)	80.96 (5)	0.11	0.001	0.000

ing-generation college students. The goodness of fit was $\chi^2_{SB} = 246.02$, $df = 195$, $p < 0.001$. The fit indexes were CFI of 0.96, TLI of 0.95, RMSEA of 0.06 with 90% confidence interval of [0.047, 0.062], and an SRMR of 0.05. Overall, the fit indexes for continuing-generation college students' model suggest good overall model fit.

5.5 Hypothesis 1: interest and recognition mediate performance/competence onto the engineering identity measure

Prior work has established a mediating relationship of interest and recognition from performance/competence beliefs to engineering identity [24, 31]. Similarly, prior work has found no significant direct effect from performance/competence beliefs to engineering identity [24, 31, 50]. We used the same structure from previous work to develop our models for both groups of women. We found that performance/competence beliefs were fully mediated by interest and recognition in predicting the overall measures of engineering identity, consistent with prior work [24, 31, 50].

Performance/competence beliefs positively predicted interest in engineering for first-generation college students ($\beta = 0.63$, $p < 0.001$) and continuing-generation college students ($\beta = 0.72, p < 0.001$). In turn, interest predicted the engineering identity item for first-generation college students ($\beta = 0.41$, $p < 0.001$) as well as for continuing-generation college students ($\beta = 0.18$, $p < 0.01$). Similarly, performance/competence beliefs also positively pre-

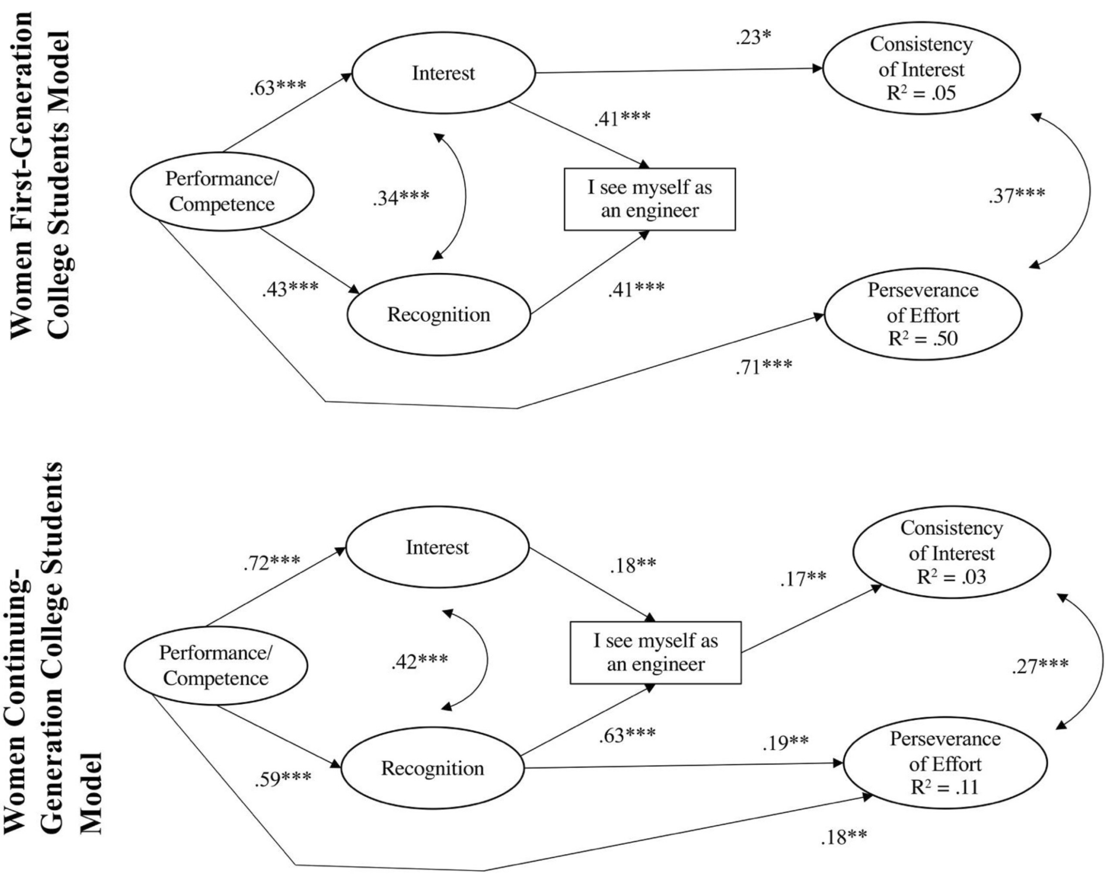

Fig. 3. Two independent structural equation models demonstrating the relationship between engineering identity building constructs, grit consistency of interest and perseverance of effort. Only significant paths are shown.

Table 5. Summary of structural equation model

Summary of Path Analysis	First-Generation College Students	Continuing-Generation College Students
	β	β
Performance/Competence → Interest	0.63***	0. 72***
Performance/Competence → Recognition	0.43***	0.59***
Performance/Competence → Grit–Perseverance of Effort	0.71***	0.18**
Performance/Competence → Grit–Consistency of Interest	–	–
Interest → Engineering Identity	0.41***	0.18**
Interest → Grit–Consistency of Interest	0.23*	–
Interest → Grit–Perseverance of Effort	–	–
Recognition → Engineering Identity	0.41***	0.63***
Recognition → Grit–Perseverance of Effort	–	0.18**
Recognition → Grit–Consistency of Interest	–	–
Engineering Identity → Grit–Consistency of Interest	–	0.17**

Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

dicted beliefs about being recognized as someone that can do engineering for first-generation college students (β = 0.43, p < 0.001) and continuing-generation college students (β = 0.59, p < 0.001). In turn, being recognized as an engineer was predictive of seeing oneself as an engineer for first-generation college students (β = 0.41, p < 0.001) and continuing-generation college students (β = 0.63, p < 0.001). The results of both models indicate that it is not sufficient to feel that one can do well in engineering (i.e., performance/competence beliefs). Rather, women must author their identities as engineers by simultaneously being interested in the subject, feeling recognized by others, and believing that they can perform well in their engineering coursework.

5.6 *Hypothesis 2: first-generation college students higher self-reported interest in engineering*

We hypothesized that the model of first-generation college students would have high levels of self-reported interest in engineering, while continuing-generation college students will have moderate levels of interest in engineering. Among women, we believe a filter effect exists such that women from marginalized communities (i.e., first-generation college students) enter engineering with heightened interest in the field, which in turn supports their claim of seeing themselves as engineers. Continuing-generation college students who enter engineering may still be exploring their interest in the field. The measure, "I see myself as an engineer," was regressed onto interest in engineering, and results yielded a high estimate ($\beta = 0.41, p < 0.001$) for the first-generation college student model, while the continuing-generation college student model demonstrated moderate interest ($\beta = 0.18, p < 0.01$).

5.7 *Hypothesis 3: continuing-generation college students higher self-reported recognition beliefs*

There are many factors that support women's identity development as engineers; among them are acts of being recognized as someone that can do engineering by parents, peers, and educators. However, we hypothesized that women who are most often recognized as the type of people that can do engineering come from privileged backgrounds (i.e., higher socioeconomic status, parent(s) with a college education). When the engineering identity measure was regressed onto engineering recognition, the continuing-generation college student model had a high estimate ($\beta = 0.63$, $p < 0.001$), while the first-generation college student model had moderate self-reported levels of being recognized as an engineer ($\beta = 0.41$, $p < 0.001$). Continuing-generation college students see themselves as engineers because they perceive being highly recognized as such by their parents, instructors, and peers and less so because of their interest in engineering. First-generation college students see themselves as engineers equally through their interest in the field and their perceived recognition by parents, instructors, and peers, albeit moderately.

5.8 *Hypothesis 4: performance/competence beliefs significant for grit–perseverance of effort*

We hypothesized that beliefs about performing well and understanding engineering will be significant for grit–perseverance of effort for both models. Our analysis revealed that first-generation college students' beliefs about understanding and performing well in engineering had a high impact on their grit–perseverance of effort ($\beta = 0.71$, $p < 0.001$). In the model of continuing-generation college students, performance/competence beliefs in engineering had a small effect on their grit–perseverance of effort ($\beta = 0.18$, $p < 0.01$). Additionally, being recognized by others as someone that can do engineering had a significant effect on grit–perseverance of effort for the model of continuing-generation college students ($\beta = 0.19, p < 0.01$) but the same effect was not found in the model of first-generation college students.

5.9 *Hypothesis 5: interest in engineering is significant for grit–consistency of interest*

We hypothesized that interest in engineering would be a significant predictor for grit–consistency of interest in both models. Our analysis revealed differential relationships for both models. Interest in engineering predicted grit–consistency of interest for the model of first-generation college students ($\beta = 0.23, p < 0.05$). However, the same relationship of interest in engineering and grit–consistency of interest was not true for the model of women, continuing-generation college students.

5.10 *Hypothesis 6: seeing oneself as an engineer significant for grit–perseverance of effort and grit–consistency of interest*

Lastly, we hypothesized that seeing oneself as the type of person that can do engineering would be a significant predictor for grit–consistency of interest and grit–perseverance of effort in both models. Our analysis revealed that seeing oneself as an engineer was not predictive of grit–perseverance of effort in either model. Seeing oneself as an engineer had a significant effect on continuing-generation college students' grit–consistency of interest ($\beta = 0.17, p < 0.01$), while this single measure of engineering identity was not predictive of first-generation college students' grit–consistency of interest.

5.11 *Summary of the two models*

Our two models confirm that for first-generation and continuing-generation college students, feelings of performing well in engineering and understanding the material is not enough for authoring an engineering identity. Rather, these women author their identities as engineers by simultaneously being interested in the subject, feeling recognized by others, and feeling knowledgeable enough to understand the course material.

In both models, women's perceptions of themselves as engineers can be explained by their interest and recognition. The total variance explained for engineering identity in the model of first-generation college students was 51% ($R^2 = 0.51$). For the model of continuing-generation college student, the variance explained for engineering identity was 57% ($R^2 = 0.57$).

First-generation college students' efficacy beliefs about doing well and understanding engineering was predictive of their grit–perseverance of effort. One latent variable, i.e., performance/competence beliefs, explained 50% ($R^2 = 0.50$) of the variance for grit–perseverance of effort for first-generation college students. However, we know, to a lesser extent, what fosters grit–consistency of interest for first-generation college students. That is, only 5% ($R^2 = 0.05$) of the variance for consistency of interest could be explained.

For the model of continuing-generation college students, we know, to a moderate extent, that being recognized as an engineer and having efficacy beliefs about performing well in engineering explain 11% ($R^2 = 0.11$) of the variance for grit–perseverance of effort. Grit–consistency of interest for continuing-generation college students' can only be moderately explained, total variance of 3% ($R^2 = 0.03$), by their perceptions of seeing themselves as engineers.

6. Discussion

Our analysis revealed that when parsing women into two separate categories, first-generation and continuing-generation college students, differences emerged in the saliency of engineering identity building constructs and the constructs that predicted grit–perseverance of effort and grit–consistency of interest. First-generation college students had high interest in engineering, which, in turn, was predictive of their grit–consistency of interest. The continuing-generation college student model reported high levels of being recognized by others as the type of people that can do engineering. Seeing oneself as an engineer was predictive of continuing-generation college students' grit–consistency of interest. Being recognized as someone that can do engineering was predictive of grit–perseverance of effort in the continuing-generation college student model, while first-generation college students' beliefs about performing well and understanding the engineering content was predictive of their grit–perseverance of effort.

Interest is a powerful influencer. Studies have shown that interest has a positive effect on students' attention, goal setting, self-regulation, and serves as a motivating factor towards persisting in difficult tasks [21, 70, 71]. In our study, interest and recognition were equally predictive of first-generation college students' beliefs of seeing themselves as the type of people that can do engineering. Interest was less predictive of seeing oneself as an engineer for continuing-generation college students compared to their recognition beliefs. Our prior work, examining both men and women, has shown that first-generation college students' interest in mathematics and engineering is greater than continuing-generation college students [47, 48, 72, 73]. Interest has been described as a motivating behavior [74]; our result indicates that first-generation college students enroll in engineering programs with an increased motivation to learn about engineering topics compared to continuing-generation college students. School subjects students are drawn to are motivating factors towards a professional career in their respective areas of interest [75].

In most high schools, engineering specific courses are yet to be part of the common curriculum, thus school-related exposure to engineering prior to post-secondary education is minimal [76]. The minimal exposure to high school courses in engineering begs the question of what types of engineering-like activities are first-generation college students engaging in prior to college. Smith and Lucena's work on low-income, first-generation college students found that these students often come from backgrounds where they cannot afford or have the option to attend summer engineering camps and are instead working in manual or skilled labor venues [77]. Our prior work found that experiences such as talking about science with friends or family members, tinkering with electrical and mechanical devices, and writing computer programs or webpages was predictive of first-generation college students interest in STEM [26]. These hands-on experiences coupled with their interest in mathematics could be fueling first-generation college students' interest in engineering. Research has found that aligning one's interest with their college degree promotes higher grades and retention [78]. Similarly, the influential work of Geisinger and Raman [79] found that students reported leaving engineering because other disciplines were more interesting to them or "they found more appealing career options outside of science and engineering" [p. 919]. Together, our results and prior literature continue to emphasize the need to develop interest in all students, but that this construct of identity may be vitally important for first-generation college students, a group that is often less aware of engineering career pathways.

Recognition by parents, peers, and instructors as being the type of person that can do engineering was twice as salient for continuing-generation college students than first-generation college students. Our findings affirm a moderate positive correlation between interest and recognition for continuing-generation ($r = 0.42, p > 0.001$) and first-generation college students ($r = 0.34$, $p > 0.001$). However, continuing-generation college students did not demonstrate equally high interest in engineering compared to their counterparts. This result begs the question of whether the act of being recognized as someone that can do engineering is privileging towards particular types of students. Perhaps women in the continuing-generation college student model are seen as more legitimate peripheral participants early in their engineering programs. Lave and Wenger [80] assert that legitimate peripheral participation is "proposed as a descriptor of engagement in social practice" where learning is an integral component [p. 35]. They also add that understanding learning through legitimate peripheral participation "must involve analysis of the political and social organization of that form, its historical development, and the effects of both of these on sustained possibilities for learning" [80, p. 64].

In the first-generation college student model, interest in engineering was related to grit–consistency of interest. This contrasted with seeing oneself as an engineer being predictive of grit–consistency of interest for the continuing-generation college student model. Seeing oneself as an engineer "is the process of . . . performing an engineer self, and ultimately being thought of as an engineer" [81, p. 274].

However, engineering interest and grit–consistency of interest does not happen overnight. Duckworth [10] in her interviews with grit paragons found that interest and the consistency to stick with one's interest, despite challenges, is "followed by a *succession* of interest-stimulating experiences" [p. 101]. Likewise, interest in one's career occupation is followed by "a little bit of *discovery*, followed by a lot of *development*, and then a lifetime of *deepening*" one's interest [10, p. 103]. Lastly, a relationship exists between grit and a growth mindset; one report affirmed that "children who have a growth mind-set tend to be grittier" [82, p. 13].

7. Limitations and future direction

Our study represents one specific point in time, and due to this cross-sectional survey design, causal relationships cannot be inferred or concluded. Given that research on grit is at its infancy, some scholars argue that grit is a repackaged measure of conscientiousness [36], one of the Big-Five personality traits. Research proving and disproving that grit is a distinct personality trait when compared to conscientiousness can be found [83, 84]. However, more empirical research is required to understand the distinction between the two. Similarly, few studies have sought to understand how grit predicts engineering students' perseverance and achievement, with the exception of a study by Choi, Myers, and Loui [29].

Critiques of grit, among educational researchers and in public forums, have noted that "grit differentiates and divides people on a hierarchy of values" [28, p. 4]. When considering students' sociocultural context (e.g., students from high poverty backgrounds), the concept of grit may not consider higher levels of stress, structural barriers, school inequalities, and the limited social support for academic achievement these students may face [22, 85]. Future research should examine the role psychological constructs, environment, and motivational factors play in fostering grit.

Missing from this analysis is a longitudinal account of how grit can develop over time with respect to the engineering identity building constructs. We know from prior work that engineering students' recognition and performance/competence beliefs are higher in their fourth year compared to their first- and second-year [86]. Perhaps certain engineering identity building constructs will become more salient than others in fostering grit as these students continue in their programs. This point is particularly relevant for first-generation college students whose experiences in engineering over time afford them more interactions with others in the field and more opportunities to be recognized as a person who can do engineering. Likewise, the experiences in an engineering program can give continuing-generation college students opportunities to experience college, and engineering achievement, in individual ways that are distinct from those of their family members who went to college. This further supports the need for longitudinal studies of grit and engineering identity development and the relationships between the two.

8. Conclusion

In summary, through our quantitative analysis of survey data from first-generation and continuing-generation college students in engineering, we found differences in engineering identity constructs (specifically recognition by others as a person who can do engineering and interest) that relate to aspects of grit–perseverance of effort and grit–consistency of interest. Specifically, first-generation college students' grit–perseverance of effort was related to feelings of competence, while continuing-generation college students' feelings of competence was related to recognition by others. First-generation college students' grit–consistency of interest was related to their initial interest in engineering, whereas grit–consistency of interest was related to continuing-generation college students' feelings of seeing themselves as engineers (although this was a weak relationship). Similarly, grit–perseverance of effort was related to first-generation college students' feelings of competence, whereas grit–perseverance of effort was strongly related to recognition by others for continuing-generation college students (again, a weak relationship). For the single item response, "I see myself as an engineer," recognition by others was strongly related for continuing-generation college students whereas interest in engineering was strongly related for first-generation college students. Within these results, there is an emerging trend with respect to the influence of external factors (recognition by others) for continuing-generation college students versus a more internal source of influence (feelings of competence and initial interest in engineering) for first-generation college students.

These results point to the role and possible differential exposure of recognition by others for continuing-generation college students, and the importance of developing an interest in engineering and sense of competence for first-generation college students in engineering. It further highlights the importance of taking an intersectional approach to studying engineering identity development and designing ways to recognize students that are responsive to their multiple identities. It is important to take into consideration which aspects of developing an engineering identity are key to success for different groups of students.

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