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Understanding How Engineering Identity and Belongingness Predict Grit for First-Generation College Students

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Abstract

Increasing the participation of underrepresented students, including first-generation college students, in engineering plays a central role in sustaining the U.S. research and innovation capacity. Diversity continues to be recognized as an asset in engineering. However, we also know that the culture of engineering has an implicit assumption about who can be and who is recognized as an engineer. There is also a complex relationship between participation in a community of practice and identity. Diverse students must not only author an identity as an engineer but also must grapple with how that identity, historically constructed as white and masculine, becomes a part of how they see themselves.

This research study uses structural equation modeling to examine how first-generation college students' engineering identity and sense of belongingness in engineering serve as mediators for students' grit in terms of persistence of effort and consistency of interest. Results reveal that engineering identity has a positive direct effect on students' sense of belongingness. Both engineering identity and belongingness have a positive direct effect on persistence of effort but were not significant predictors of consistency of interest. Additionally, belongingness is a mediator between engineering identity and persistence of effort. These results begin to uncover how grit is not a stand-alone measure and defies the idea that some students have it while others do not. Persistence of effort is present for first-generation college students when they see themselves as the kinds of people that can do engineering and feel a sense of belongingness within the field. The results of this work highlights ways to support grit development in first-generation college students.

Introduction

First-generation college students face numerous unique challenges within higher education that offer particular opportunities for research and interventions to improve their enrollment and retention. This population has potential to *add* to the field of engineering as they bring with them unique lived experiences. First-generation college students have been described as invisible innovators [1]. Smith and Lucena [1] argue if first-generation college students' funds of knowledge are equally valued knowledge as that of the dominant engineering culture, these students' can be legitimate creators of knowledge and contribute to innovative solutions in the engineering enterprise. However, for students to see themselves as legitimate creators and contributors of knowledge in engineering they must first see themselves as engineers by participating in the engineering community of practice. Forming an identity within a community of practice is subsequently tied to feeling as though one belongs in that community. When students feel as though they belong in engineering and have developed an engineering identity, they are more likely persist. In this study, we move away from using degree completion or GPA as a measure of persistence for first-generation college students and focus on the personality trait of grit.

First-generation college students by definition come from families "where neither parent had more than a high-school education" [2, p. 249], [3]. Studies also affirm that while not all first-generation college students are of low socioeconomic status, most of these students are [4]–[7]. Therefore, our conceptualization of first-generation college students encompasses students who are of low socioeconomic status. In contrast, continuing-generation college students are those who report having at least one parent completing post-secondary education (i.e., college graduate; [8]).

The general narrative of first-generation college students has portrayed a deficit perspective, focusing on lack of student attainment or prior support. Scholars have often focused on lack of academic preparation [8], [9], inadequate familial support [10], challenges towards achieving future career goals [11], struggles in the transitions from secondary to postsecondary education [2], or lack of social and cultural integration [12]. We move away from this approach and instead seek to highlight assets first-generation college students bring with them into an engineering program. Our prior work has shown that first-generation college students demonstrate greater future career satisfaction for inventing/designing things, developing new knowledge and skills, applying math and science, and supervising others when compared to continuing-generation college students [13]. The future career satisfaction measures in our prior study reflect the future outcomes students desire in their careers [14], which can be a source of motivation for learning [15], [16].

In another study using data from first-year engineering students, first-generation college students had, on average, statistically significant greater engineering and mathematics role identity beliefs than did their continuing-generation peers. Additionally, first-generation college students had significantly greater interest, beliefs about performing well and understanding engineering and mathematics concepts than continuing-generation college students [17]. Studies have found that students who "… leave engineering reported that other majors were more interesting ... or that they found a more appealing career option outside of science and engineering ..." [18, p. 919]. Our previous study suggest that first-generation college students at the start of their college trajectory enter engineering with greater interest than their peers [17]. Hidi and Renninger found that interest has a positive impact on persistence and effort, motivation, and learning in the classroom [19].

In another study examining factors that predicted first-generation college students' future identification as engineer, interest in engineering accounted for 17.5% of the variance while feelings of belonging contributed the highest variance, 34.6% [20]. Boone and Kirn [21] further investigated two domains of belongingness, belonging in the engineering classroom and belonging in the engineering major for first-generation college students with two or more years of engineering course work. Their study found that compared to their counterparts, first-generation college students were more likely to feel a sense of belonging in the classroom and in their engineering major. Boone and Kirn's [21] study was conducted at a Southwestern land grant institution with a "higher than normal percentage" of first-generation college student enrollment [p. 18]. Perhaps the higher enrollment of first-generation college students allowed these students to see more people like them in their engineering majors. These studies help to shape a different narrative of first-generation college students that is focused on the assets they bring to engineering rather than what they lack.

To continue shifting the narrative, we will examine how first-generation college students' beliefs of seeing oneself as an engineer and subsequently feeling as though one belongs in engineering fosters their perseverance and passion towards completing their engineering degree. In the subsections that follow, we introduce the three frameworks used in this study: engineering identity, belongingness, and grit.

Theoretical Frameworks

Engineering Identity

Learning is an ongoing process of participating in a community of practice, and becoming a member involves taking on roles, behaviors, and attitudes that are defined and shared within that community [22], [23]. Identity is important as it supports students' commitment to the engineering field, and students who are further along in their engineering degrees demonstrate more solidified engineering identities [24]. Not only does commitment to a discipline result from identifying with the discipline, but also, the process of learning to participate in a community fosters an identity in the discipline.

Identity, in this study, is defined as "being recognized as a certain 'kind of person,' in a given context," [25, p. 99]. This context places the focus on an individual's social performance rather than their unique being [25], [26]. The authoring of oneself in a specific domain (e.g., engineering or science) is based on Gee's framing of identity, and in this study, we focus on the domain of engineering [27], [28]. The authoring of oneself within the engineering context is done through three interrelated dimensions: interest, recognition, and performance/competence. An individual cannot be recognized as a certain kind of person unless they make visible (*perform*) their *competence* in a particular domain [29].

Recognition is therefore both an external manifestation and internal state, both of which are required for identity development [29], [30]. Carlone and Johnson defined *performance* in a science identity context as "relevant scientific practices (e.g., ways of talking and using tools)" and *competence* as "knowledge and understanding of science content" [24, p. 1191]. However, several 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 [28], [31]. 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 [31]. Scholars who study interest have 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" [32, p. 2].

Belonging in Engineering

Baumeister and Leary [33] posited that people are "naturally driven towards establishing and sustaining belongingness" [p. 499]. Strayhorn [34] asserts that a sense of belongingness "is a basic human motivation and all people share a strong need to belong" [p. 1]. In this study, the definition of belongingness or a sense of belonging in college is borrowed from the work of Strayhorn [34] who stated,

> [a] sense of belonging refers to students' perceived social support on campus, a feeling or sensation of connectedness, the experiences of mattering or feeling cared about, accepted, respected, valued by, and important to the group (e.g., campus community) or others on campus (e.g., faculty, peers; p. 17).

Students who experience a sense of belonging are more likely to display "intrinsic motivation, … establish a stronger sense of identity, … and regulate their own behavior in the classroom consistent with social norms" [35, p. 331]. Research studies have found that a sense of belonging in school is connected to students' coping skills (i.e., skills acquired that helps one manage difficult endeavors) [36], motivation [33], [37], [38], and school-related participation [39].

Belongingness is most significant in environments such as engineering classrooms or programs in which first-generation college students experience different and unfamiliar situations or where they are more "likely to feel marginalized, unsupported or unwelcomed" [34, p. 63]. In a study with 42 participating countries, low socioeconomic students (i.e., in the lowest national quartile for each respective country), single-parent family and foreign-born students were most likely to feel a lack of belongingness in their respective schools [40]. Chiu and colleagues [41] stated that "context is important to a person's sense of belonging" [pp. 176]. Therefore, it was important to understand the distinction between students' sense of belonging in the field of engineering and students' sense of belonging in their engineering classroom.

Grit: Persistence of Effort & Consistency of Interest

A report by the U.S. Department of Education identified grit, among other non-cognitive factors, as critical for success in the 21st century, beyond test scores and intellect [42]. Twenty-first century competencies include cognitive, intrapersonal, and interpersonal competencies, where grit is categorized as an intrapersonal domain [43]. This focus has put grit into the national spotlight for all students, including underrepresented students like first-generation college students.

Studies on grit are still emerging but appeared in literature as a topic of study in education as early as 2007. Grit is defined as "perseverance and passion for long-term goals," thus enabling individuals to work hard and stick to their passion and goals; "the gritty individual approaches achievement as a marathon; his or her advantage is stamina" [44, p. 1087]. Grit has been conceptualized as distinct from other personality traits. Although grit may resemble the Big Five personality trait of conscientiousness, in aspects of achievement, grit differs in its emphasis on long-term stamina, emphasizing the role of effort and interest in the long run [44]. Studies using the grit scale (i.e., persistence of effort and consistency of interest) found that grit "accounted for significant incremental variance in success outcomes over and beyond IQ" and the Big Five personality trait conscientiousness [44, p. 1098], [45]. Gritty individuals, in the studies conducted by Duckworth and colleagues [44], [45], were found to have higher levels of education, had fewer career changes, and earned a higher GPA (despite having lower SAT scores) than their less gritty counterparts. Likewise, in a study of West Point Cadets, grit was found to be a better predictor of first summer retention when compared to a Whole Candidate Score which consisted of a "weighted composite of high school rank, SAT score, participation in extracurricular activities and a standardized physical exercise evaluation" [45, pp. 170–171]. Another 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" [46, p. 20]. Additionally, when grittier participants received feedback that they were failing, they were more likely to persist than their less gritty peers [46]. In a study of first-year engineering students, grit in terms of perseverance of effort was found to be a significant predictor of one- and two-year engineering retention, even after controlling for mathematics grade [47].

Current Study

Overall, our model hypothesizes that engineering identity and belongingness predict two forms of grit: persistence of effort and consistency of interest. Our model hypothesizes a path from engineering identity to belonging in engineering, rather than the reverse, because we believe students must first develop an interest in the subject, obtain recognition by others and have internalized beliefs that they can understand and perform well in engineering to subsequently develop feelings of belonging. Previous research has established a relationship between interest, recognition, and performance competence in measures of engineering identity [27]. The path from performance/competence to engineering identity mediated by interest and recognition was built in our model to be consistent with prior work on mathematics identity [48] and physics identity [27], [49]. Prior work has also found a non-significant direct path from performance/competence to engineering identity; however, this result is for all students rather than first-generation college students. In this paper, we examine this structure in this study for first-generation college students. Boone and Kirn [21] and Smith and colleagues [50] identified multiple domains of belonging, belonging to the classroom and belonging to the engineering major, which we will use in this study.

To examine if an engineering identity and belongingness serve as mediators for first-generation college students' measures of grit: persistence of effort and grit: consistency of interest, we test the following hypotheses:

1. Performance/competence would have a direct effect on engineering identity. (path a)
2. Engineering identity will have a direct effect on both grit: persistence of effort and grit: consistency of interest. (path d; path e)
3. Belonging in an engineering major and belonging in an engineering classroom will mediate the pathway between engineering identity and grit: persistence of effort (path b → h; path c → g).
4. Belonging in engineering major and belonging in engineering classroom will mediate the pathway between engineering identity and grit: consistency of interest (path b → f; path c → i).
5. Belonging in engineering and belonging in an engineering classroom will be correlated (path j).
6. Grit: persistence of effort and grit: consistency of interest will have correlated residuals (path k).

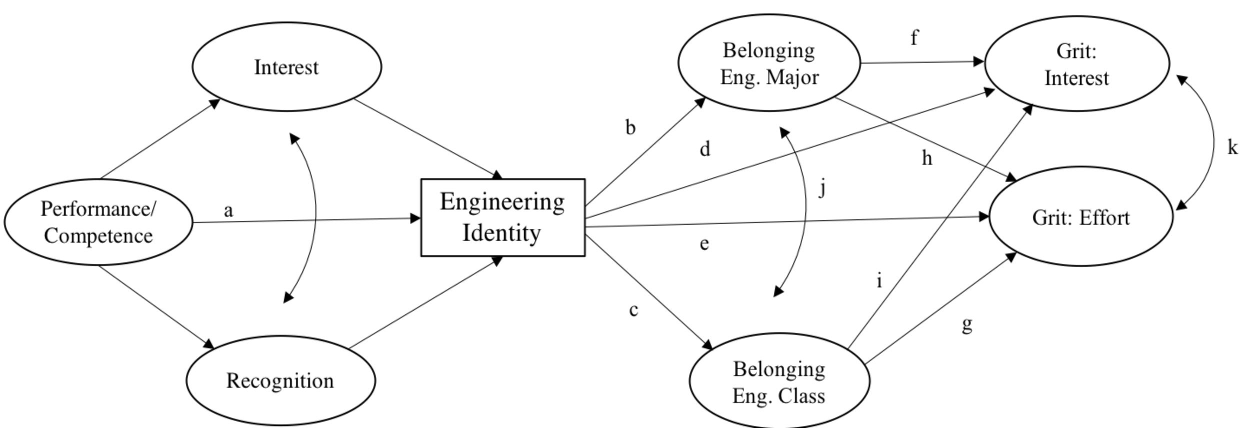

Figure 1. Hypothesized Structural Equation Model

Method

In the Fall of 2015, during the first two weeks of class, *n* = 2,916 first-year, first-semester engineering students participated in a survey administered via paper-and-pencil. The survey was administered at three participating land-grant institutions and one Hispanic-Serving Institution (HSI) in the U.S. in their respective introductory to engineering courses. The survey was designed to measure several factors related to how students felt about their place in the engineering community, their attitudes towards engineering, and their perceptions about their future in engineering. In this study, we examined survey data for a subset of the population, first-generation college students. Students were asked to indicate their parents' level of education, and those who reported both parents/guardians obtained "less than a high school diploma," "high school diploma/GED," or "some college or associate/trade degree" were classified as first-generation college students. Students who reported parent(s)/guardian(s) completed a "bachelor's degree" or "master's degree or higher" were classified as continuing-generation college students.

Of the overall 2,916 students who completed the survey, 72% ($n_1 = 2,092$) were considered continuing-generation college students, 20% ($n_2 = 596$) were first-generation college students, and 8% ($n_3 = 228$) did not report their parents' educational background. Students who did not report parent's level of education were removed from the study, as their first-generations status was not reported. The distribution of first-generation college student participants from each institution is as follows: Southwestern land grant institution $n = 172$ (33%), Southern land grant $n = 125$ (24%), Midwestern land grant $n = 97$ (19%), and HSI $n = 120$ (23%). In our sample, 24% of students identified as female, and 76% identified as male. The race/ethnicity breakdown is 9% Asian, 7% African American/black, 30% Latino/a or Hispanic, 1% Native American or Alaska Native, 1% Native Hawaiian or other Pacific Islander, 7% multiple race/ethnicities, and 45% white.

Measures

All items were assessed using a 7-point anchored numeric scale, ranging from 0–strongly disagree to 6–strongly agree. The measurement model of each latent variable has shown strong validity evidence in previous work on engineering identity measures [27], belongingness [50], [51] and grit [44]. Students were asked to rate the extent to which they agreed or disagreed with statements pertaining to interest, recognition and performance/competence in engineering. The engineering identity measures included three items measuring interest, four items measuring recognition, and five items measuring performance/competence. A single item was used to capture students' overall engineering identity: *I see myself as an engineer*. Two measures of belongingness were used: general belongingness in engineering (three items) and belonging in an engineering classroom (two items). Students were asked to rate how they felt they fit in engineering and belonged in engineering community. Two measures of grit were used in this study, grit: persistence of effort (four items) and grit: consistency of interest (three items). Students were asked to answer how closely the following questions described them to determine their grit [51].

Data Analysis

Data were screened to assess whether assumptions of univariate and multivariate normality were violated using skewness, kurtosis and Mardia's Test. Skewness within an absolute value of 2.0 or greater and kurtosis of an absolute value of 7.0 or greater indicates a violation of univariate normality [52]. These absolute value ranges are based on data with large sample sizes $n > 300$ [53]. Mardia's Test for multivariate normality examines "skewness and kurtosis coefficients as well as their corresponding statistical significance" [54, p. 4]. Measure of construct reliability was examined using Cronbach's alpha, where coefficients with 0.70 to 0.95 indicates that as a set, the items are closely related [55]. If the data were determined to be non-normal, robust corrections were used in the modeling.

Structural equation modeling (SEM) was used to test the hypotheses related to the overall research question of to what extent the engineering identity constructs and belongingness constructs serve as mediators for students measures of grit: persistence of effort and grit: consistency of interest. The first step in conducting SEM is to test the measurement model of each latent variable (i.e., engineering identity constructs, belongingness, and grit), using confirmatory factor analysis (CFA). CFA model fit was assessed using the following indexes: Chi-square goodness of fit, Comparative fit index (CFI), Tucker Lewis Index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). Chi-square goodness of fit tests if the covariance matrix equals the observed covariance matrix; however, this test is biased against sample sizes greater than 400 [56] but is commonly reported. CFI "evaluates the fit of a user-specified solution in relation to a more restricted, nested baseline model" and has a range of 0.0 to 1.00, where 1.00 implies good model fit [57, p. 84]. TLI is another comparative fit index and has acceptable values above 0.90 [57]. To test for parsimony, the RMSEA is a widely-recommended index. It is an "error of approximation" index because it determines how well the model fits within the population [57], [58]. A close fit would indicate the RMSEA is less than or equal to 0.05 and less than or equal to 0.08 moderate fit [57], [59]. Lastly, the SRMR is "viewed as the average discrepancy between the *correlations* observed in the input matrix and the correlations predicted by the model" [57, p. 82]. SRMR values fall between 0.0 to 1.0, where 0.0 would indicate perfect fit. After testing the measurement model fit using CFA, the second step is to test the structural model fit of the hypothesized model. Structural model fit for the hypothesized SEM was tested using the same fit indexes.

All analysis were conducted using the R programming statistical language version 3.4.3 [60]. The procedures for conducting the confirmatory factor analysis and latent variable modeling analysis was using the lavaan package [61].

Results

Upon examination, univariate normality was found to be within acceptable range of skewness (within an absolute value of less than 2.0) and kurtosis (absolute value of less than 7.0). Mardia's test yielded estimates of multivariate skewness $\gamma_{1,p}$ = 121. 83, $p < .001$ and estimates of multivariate kurtosis $\gamma_{2,p}$ = 986.80, $p < .001$. The significant p-values indicate violation of multivariate normality. Thus, to correct for non-normality, a robust maximum likelihood (MLM) estimator was used in the analysis. A robust MLM estimator provides similar parameter estimates as maximum likelihood; however for non-normal, continuous indicators, using robust MLM also corrects both the model X^2 and standard errors of the parameter estimates for deviations from a normal distribution [57], [62]. The X^2 statistic produced by MLM is a Satorra-Bentler scale (X^2_{SB}). MLM requires a listwise deletion method [61]; therefore, cases with missing data on any variable were removed from the analysis. The measurement model for each latent variable and structural model were tested for model fit, as shown in the subsection that follows.

Measurement Model

A confirmatory factor analysis was conducted separately for all latent constructs to determine how well the survey items measured the intended constructs. Overall, the fit indexes suggest that we have good model fit for all three models, as shown in Table 1. The Satorra-Bentler chi-square goodness of fit was significant for all latent constructs; however we know that this test is biased against large sample sizes [63]. The CFI and TLI values were above 0.90, where values above 0.90 reflect good model fit while values closer to 1 implies "perfect" model fit [57], [64] RMSEA values ranged from .04 to .07. These values were less than .08, indicating moderate model fit [57], [59]. Brown [57] notes that additional support for fit using RMSEA is evidence by having a 90% confidence interval upper limit value below 0.08, which was found for our three constructs. Lastly, SRMR values ranged from 0.01 to 0.04. All values were less than 0.08 indicating acceptable fit; that is, the observed correlation matrix closely resembles the predicted correlation matrix [57].

Table 1 Summary of Fit Statistics for Confirmatory Factor Analysis Models

Model	X^2_{SB}	*df*	CFI	TLI	RMSEA	90% CI for RMSEA	SRMR
Engineering Identity constructs	96.71	31	.97	.95	.06	(.05, .07)	.04
Belongingness constructs	7.33	4	.99	.99	.04	(.00, .06)	.01
Grit constructs	49.75	13	.96	.93	.07	(.05, .08)	.04

Note. CFI = Comparative Fix Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation; CI = confidence interval; SRMR = Standardized root mean square residual.

The fit indexes included in Tables 1 and 2 provide a more detailed description of the model fit for the engineering identity, belongingness, and grit constructs. Table 2 includes unstandardized and standardized factor loadings, standard error, item reliability (R^2) construct reliability (α), and average variance extracted. All standardized factor loadings were above the 0.45 minimum. Item reliability was evaluated using the multiple squared correlation (R^2), and variables for the engineering identity constructs and belongingness constructs were above 0.50 indicating the items measure above 50% of the variance. Item reliability in the two grit constructs ranged from 0.31 to 0.69. The construct reliability, examined using Cronbach α, for the seven latent variables were between 0.77 to 0.90, all above 0.70, indicating good construct reliability [55]. The amount of variance captured by each construct in relation to the amount of variance due to measurement error should be above 0.50, whereas values below 0.50 indicate that the "variance due to measurement error is larger than the variance captured by the constructs and the validity of the individual indicator" [65, p. 46]. The average variance extracted for each latent variable ranged from 0.50 to 0.80. All of these values were above the 0.50 cutoff value [65].

Table 2 Confirmatory Factor Analysis Estimates and Fit Indexes

Latent Variables	Indicators	Unstandardized/ Standardized Factor Loadings	*SE*	Item reliability (R^2)	Construct reliability (α)	Average variance extracted
Interest					.89	.77
	I am interested in learning more about engineering.	.56***/.76	.03	.59		
	I enjoy learning engineering.	.86***/.93	.03	.88		
	I find fulfillment in doing engineering.	.86***/.86	.04	.77		
Recognition					.83	.63
	My parents see me as an engineer.	.95***/.71	.05	.48		
	My instructors see me as an engineer.	1.09***/.81	.05	.69		
	My peers see me as an engineer.	1.18***/.84	.05	.71		
	I have had experiences in which I was recognized as an engineer.	.97***/.52	.06	.27		
Performance/Competence					.93	.76
	I am confident that I can understand engineering in class.	.91***/.85	.04	.76		
	I am confident that I can understand engineering outside of class.	.82***/.84	.04	.81		
	I can do well on exams in engineering.	.92***/.81	.04	.67		
	I understand concepts I have studied in engineering.	90***/.82	.04	.81		
Belonging: Engineering Major					.89	.72
	I feel comfortable in engineering.	.92***/.82	.04	.72		
	I feel I belong in engineering.	.99***/.88	.04	.81		
	I enjoy being in engineering.	.82***/.86	.03	.66		
Belonging: Engineering Classroom					.89	.80
	I feel supported in my engineering class.	.92***/.85	.04	.73		
	I feel that I am part of my engineering class.	.99***/.94	.04	.83		
Grit: Persistence of Effort					.72	.50
	I have overcome setbacks to conquer an important challenge.	.65***/.56	.05	.31		
	I am a hard worker.	.66***/.69	.04	.48		
	I finish whatever I begin.	.89***/.78	.05	.61		
	I am diligent.	.88***/.83	.05	.69		
Grit: Consistency of Interest					.77	.54
	My interests change from year to year.	1.04***/.64	.07	.41		
	I have been obsessed with a certain idea about a project for a short time but later lost interest.	1.26***/.76	.07	.58		
	I often set a goal but later choose to pursue a different one.	1.27***/.83	.06	.69		

Note. *** $p < .001$, acceptable values of $R^2 > .50$, $\alpha > .70$, and average variance extracted > .50

Structural Model

Once acceptable model fit was established for each of the latent constructs, the hypothesized model structure was tested. Paths that were non-significant were removed from the final to obtain the most parsimonious model. The resulting model is shown in Figure 3. The Satorra-Bentler adjusted chi-square test for goodness of fit was $X^2_{SB} = 956.75$, $df = 261$, $p < .001$. The fit indexes were CFI of 0.92, TLI of 0.91, and RMSEA of 0.067 with confidence interval of 0.062 to 0.071. Overall, the fit indexes suggest we have good structural model fit.

We found no significant direct effect from performance/competence to engineering identity. This result is consistent with prior research that found no significant direct effect of performance/competence in mathematics [48]. Rather, our model confirmed a significant mediation of interest and recognition from the pathway of performance/competence to engineering identity. Performance/competence beliefs positively predicted first-generation college students interest in engineering, $\beta = 0.73$, $p < .001$. Similarly, performance/competence beliefs also positively predicted first-generation college students' beliefs about being recognized as someone that can do engineering, $\beta = 0.53$, $p < .001$. We interpret these results to mean that if students do not feel that they can do well and understand engineering, they are less likely to be interested or feel recognized in engineering. In our model, recognition had the highest direct effect on engineering identity, $\beta = 0.54$, $p < .001$, following interest, $\beta = 0.28$, $p < .001$. Consistent with prior work, our model found a significant correlation between interest in engineering and recognition by others as an engineer, correlation = 0.27, $p < .001$ [49]. Given that our data is cross-sectional, we cannot determine if interest precedes recognition or vice versa, rather we can only affirm that a correlation between the two latent variables exists. Our analysis confirms that for first-generation college students, it is not enough to feel that one can do well in engineering (performance/competence). Rather, these students must author their identities as engineers by simultaneously being interested in the subject, feeling recognized by others, and performing well in their engineering coursework. The total variance explained in relation to students' engineering identity was 48%, $R^2 = 0.48$.

Our analysis also revealed that having an engineering identity has a positive direct effect on grit: persistence of effort, $\beta = 0.23$, $p < .001$. Authoring an identity as an engineer can directly support the development of grit: persistence of effort for first-generation college students. In our model, belonging (both in engineering major and in the engineering classroom) partially mediated the relationship between engineering identity and grit: persistence of effort. The indirect pathway between engineering identity and belonging in the engineering classroom onto grit: persistence of effort was not significant. However, there was a significant direct effect from belonging in engineering classroom to grit: persistence of effort, $\beta = 0.15$, $p < .05$. There was no direct effect from engineering identity to grit: consistency of interest, and as a result this path was omitted from our model. The direct effect of belonging in engineering major to grit: consistency of interest was also significant, $\beta = 0.19$, $p < .001$.

Lastly, there was a significant correlation effect between belonging in engineering and belonging in the engineering classroom, correlation = 0.68, $p < .001$, and a significant residual correlation between grit: consistency of interest and grit: persistence of effort, residual correlation = 0.30, $p < .001$. Overall, the model explained 76% of the variance in relation to students' grit: persistence of effort, $R^2 = 0.76$ and 97% of the variance in relation to students' grit: consistency of interest, $R^2 = 0.97$.

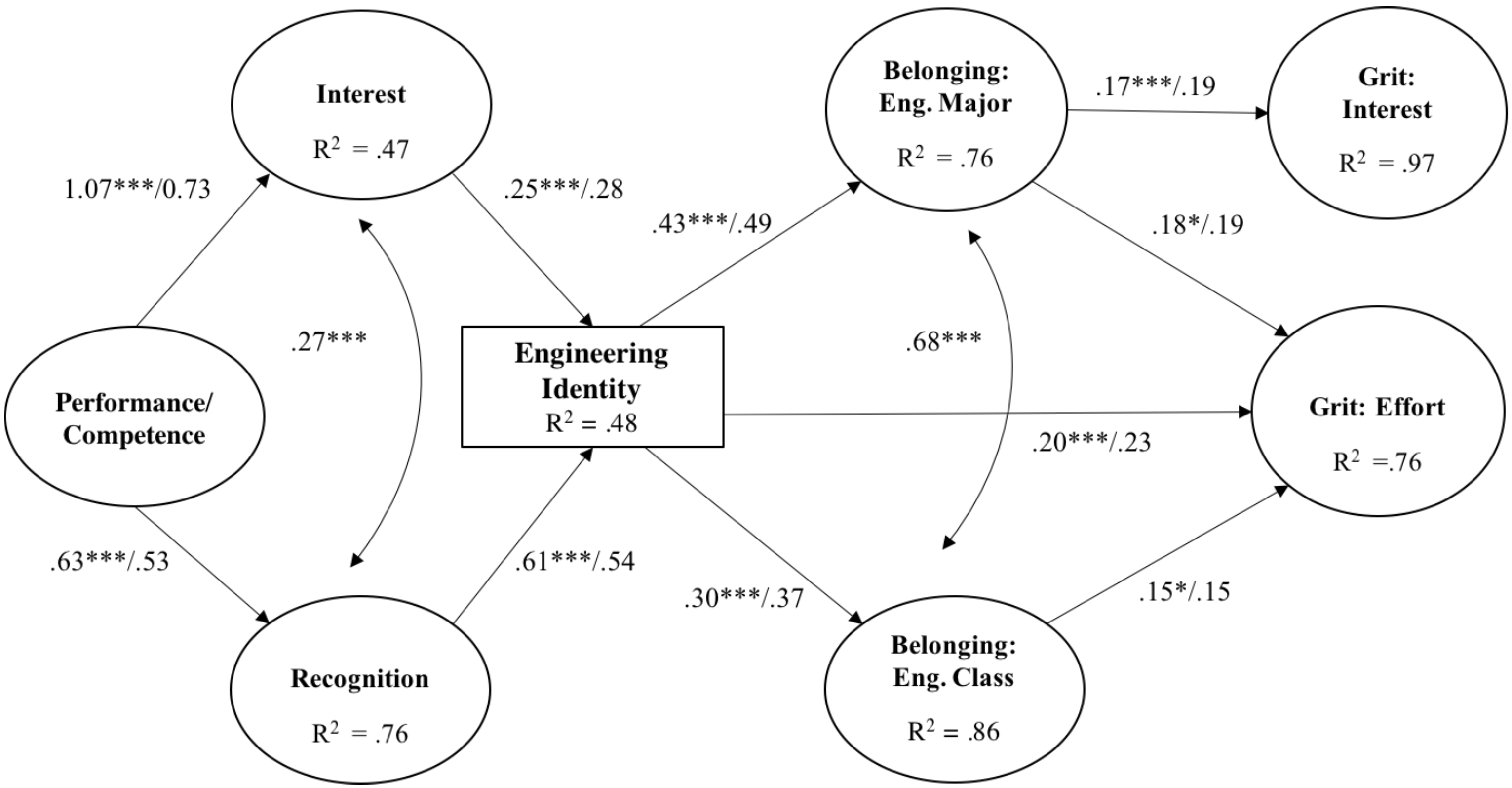

Figure 3. Results of best fitting mediation model in unstandardized/standardized form. Statistical significance is coded as * $p < .05$, ** $p < .01$, *** $p < .001$

Discussion

Most studies using grit tend to focus on how measures of grit correspond to achievement or retention. Few studies have focused on how students may develop or foster grit. This lack of empirical evidence can potentially lead researchers and practitioners to believe that grit is an innate trait that students either have or do not have. Our findings suggest that first-generation college students' measures of grit: consistency of interest and grit: persistence of effort, are predicated on feeling that one belongs in engineering and has a formulated identity as an engineer. In fact, 97% of the variance for grit: consistency of interest is explained by students self-reported measures of belonging in the engineering field. Furthermore, 76% of the variance for grit: persistence of effort is explained through students reported measures of having an engineering identity, belonging in engineering, and feeling as though one belongs in the engineering classroom. Grit has been connected to a growth mindset [66], where a growth mindset involves the belief that one's abilities are not fixed but can be developed [67].

There have been several critiques around the concept of grit among educational researchers and in public forums. A report by the U.S Department of Education noted that "persevering in the face of challenges or setbacks to accomplish goals that are … unimportant to the student, or in some way inappropriate for the student can have detrimental impact on students' learning and psychological well-being" [42, p. 93]. Similarly, when considering students' sociocultural context, the concept of grit may not take into account higher levels of stress, and the limited social support for academic achievement that students from high-poverty backgrounds may face [42]. However, by examining grit through a different approach, we can increase our understanding and framing of grit towards a more equitable perspective. That is, understanding how grit is fostered through mediums, such as feelings of belongingness and seeing oneself as the type of person that can do engineering can be a more equitable way of understanding grit. This study dispels the notion that grit is an innate trait (i.e., some students have it while others do not) by shedding light on how one's beliefs of belonging in engineering and having an engineering identity can foster grit. Additionally, this study further expands the effects of developing an engineering identity. Prior studies have found that the development of an engineering identity has important implications for academic development [24], retention [68], and for the formation of a future professional identity [69], [70]. We can also add that developing an engineering identity has a direct effect on grit in terms of persistence of effort.

Conclusion

This study examined the relationship between first-generation college students' engineering identity, belonging in engineering as a field and in the engineering classroom, and grit. We found that students' engineering identity had a direct effect on students' persistence of effort and an indirect effect (through engineering belongingness) on students' consistency of interest. Together, these results indicate that how students see themselves and position themselves within an engineering context has direct implications for how gritty they may be. For students who may not typically see themselves as engineers or see others who are like them within engineering, opportunities to foster interest, recognition, and performance/competence beliefs in engineering contexts may provide a more solid grounding for first-generation college students such that they feel they belong in engineering and have the passion to persist in engineering. This study is a first step in examining other affective constructs that may foster grit for first-generation college students. Future work will include examining the long-term effects of these identity and belonging beliefs on student success and persistence in engineering.

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